FOREST PRODUCTS JOURNAL

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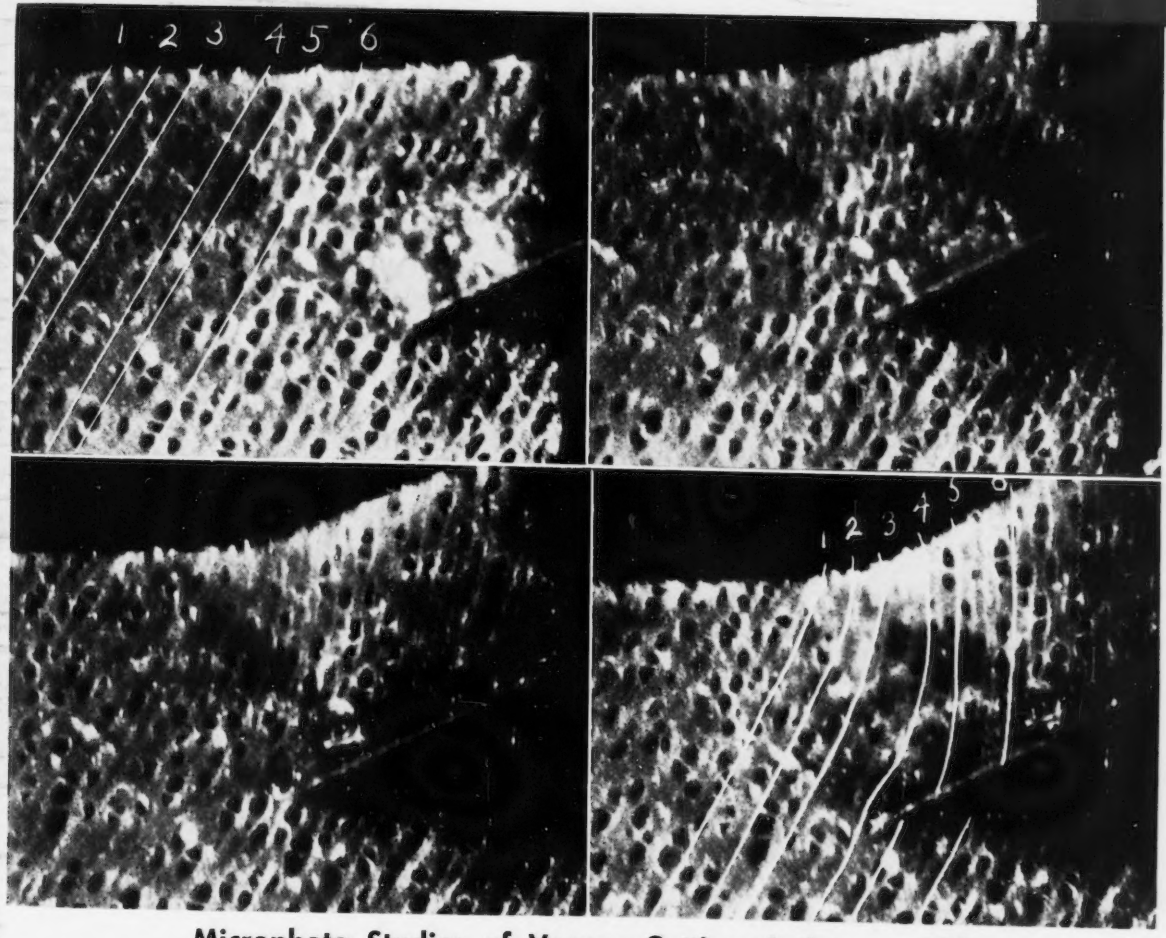

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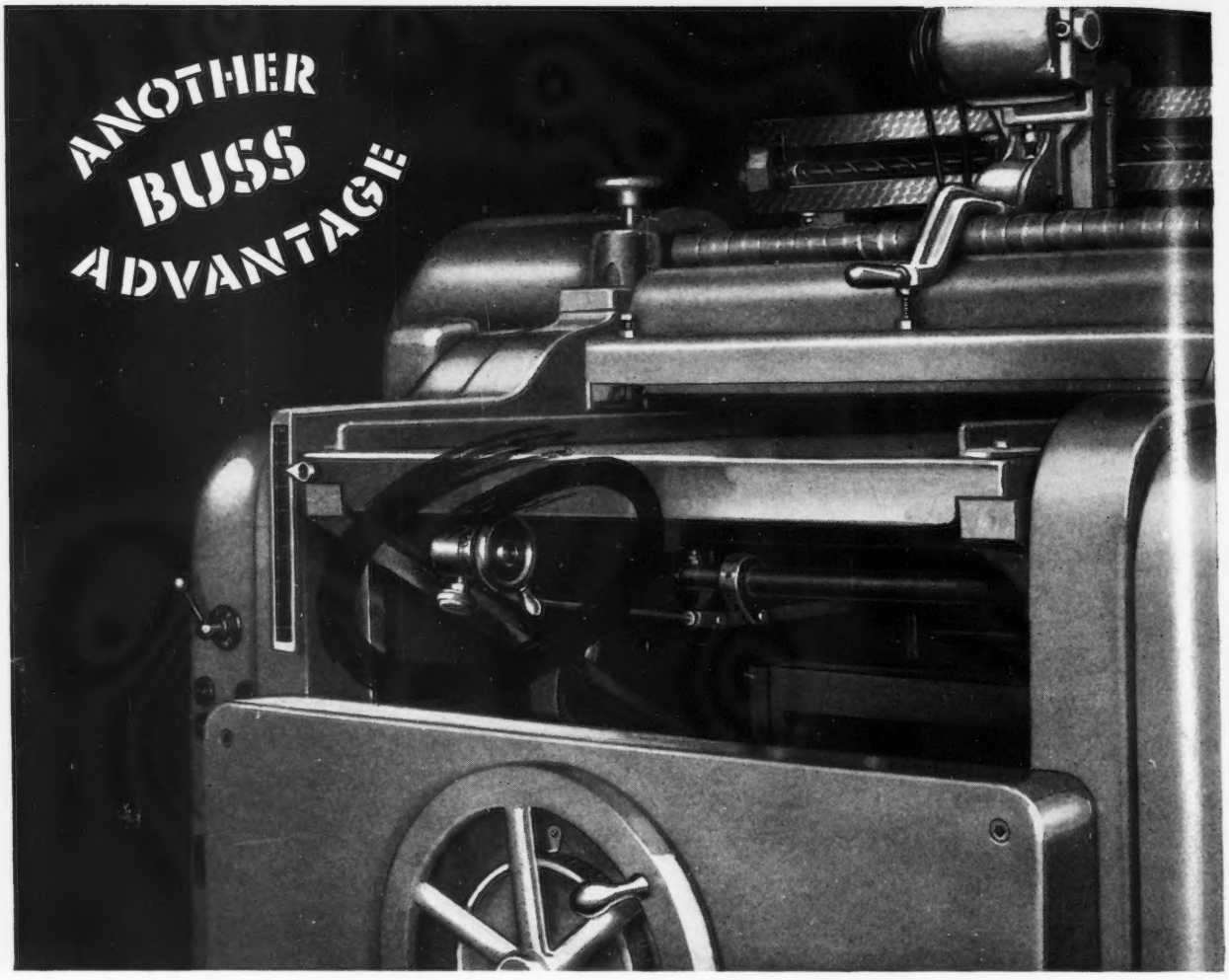

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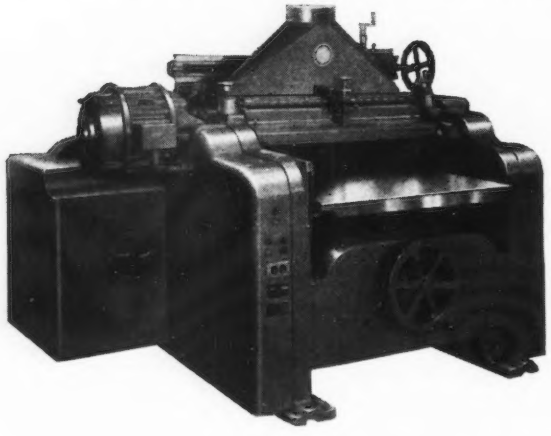

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FOREST PRODUCTS JOURNAL

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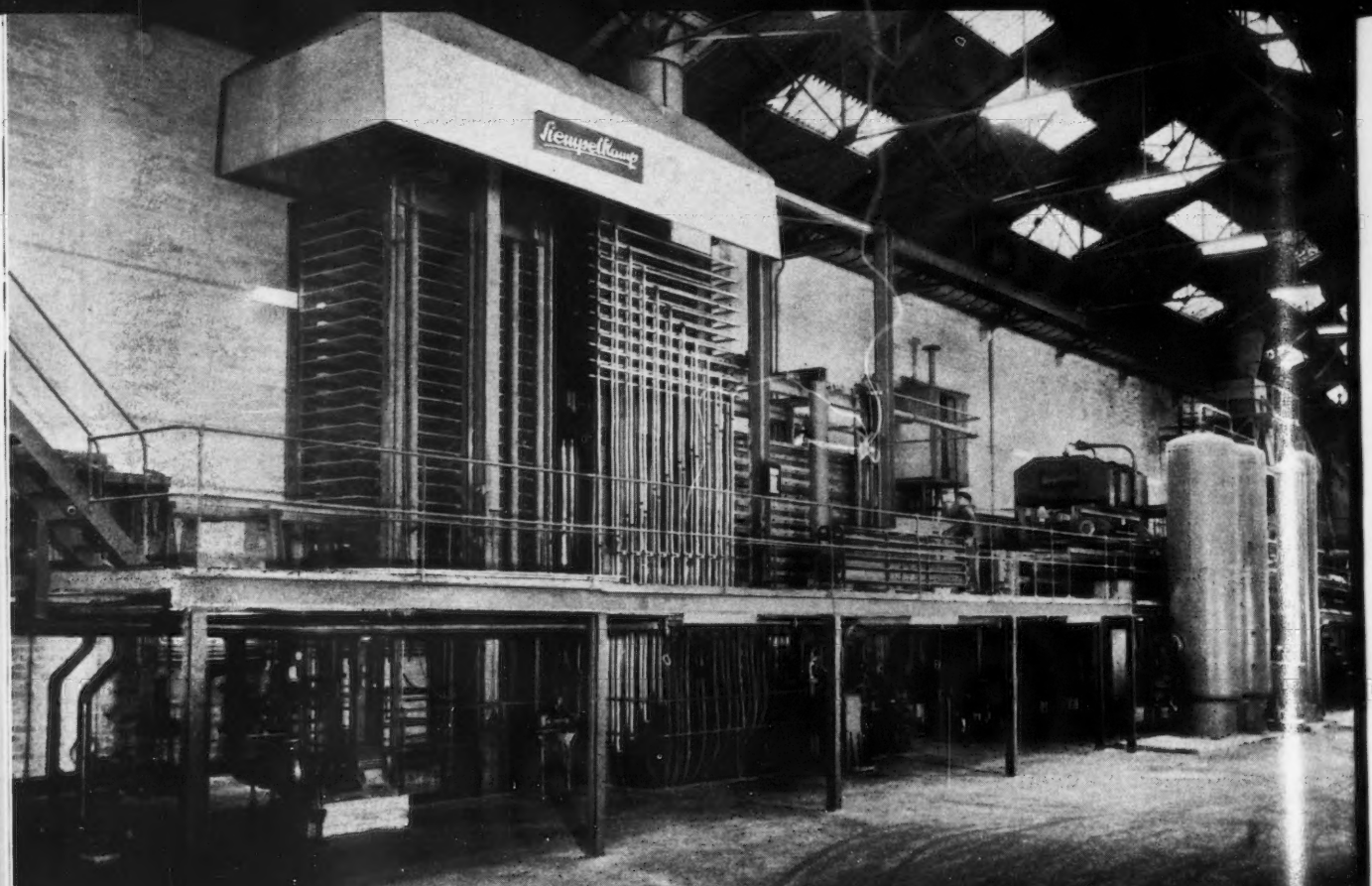

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THE PRESIDENT'S COLUMN

. H. BERRY
ing President

At the 13th Annual Meeting at San Francisco, the Section Officers Advisory Council recommended to the Executive Board that preprints of all papers presented at Annual Meetings be available at the beginning of the meeting. The matter was discussed by the Executive Board in San Francisco and referred to a committee, which was to canvass the situation, make recommendations, and poll the membership.

At the Executive Board meeting held in Chicago on November 4 and 5, discussions pro and con came up twice during the course of the meeting. Questions were raised as to the cost of printing the great number of papers for an Annual Meeting. It was felt that the bulkiness and extent of such a printing would impose almost insuperable problems in supervising the editing and production of the papers. Also, there was some question as to the number that might be brought, unless the cost became part of the registration fee at an Annual Meeting, which everyone had to pay and which would make everyone entitled to a copy of the papers. There was some feeling that publishing the papers this way would affect the *Journal* which would be deprived by this procedure of original publication, although it was recognized that the preprints would be in rough form, without the notes and editing which would accompany *Journal* publication. If the papers were bought on a voluntary basis, it would be difficult to know what price to charge, since it would be impossible to tell in advance what the sale might be. There was also some feeling that the publication of the papers would lessen attendance at the Annual Meetings, since people might read the preprints and stay away from the sessions. Opposed to this was the view that preprints would stimulate attendance and discussion.

The committee appointed at the June meeting recommended abstracts and earlier publication of papers in the *Journal*. The Board, following this recommendation, particularly since there was little time to arrange for preprints for the Montreal meeting, passed a resolution instructing the Technical Program Chairman to have the National Meeting authors adhere to the four-month requirement on completion of papers, as provided for in the proposed Division By-laws, and to provide for abstracts of papers and panel session content, which were to be prepared by the individual Division Program Chairmen. Further, the Board resolved that every attempt be made to publish all acceptable National Meeting papers in the *Journal* within four months after the National Meeting at Montreal.

Since there was considerable feeling pro and con on this question of preprints, the President of the Society, by letter, asked the members of the Executive Board to reconsider their position, and the Board members did so. At the next Board meeting, held in Chicago on January 19 and 20, 1960, there was further discussion, at the conclusion of which the Board reaffirmed, by resolution its previous position.

The Board urged that a fair trial be given the policy that it voted for.

FPRS News-Digest

Program Shaping for June 5-9 Montreal Meet

National Meeting Committee Chairmen gathered at a recent meeting held in Montreal. Front row, left to right: A. J. Petch, C. B. Dyas, W. E. DeCelles, D. K. Saunders, E. I, Holmes, J. F. McCracken, D. D. Lockhart; rear, G. Lemay, C. Bird, R. H. Gray, V. H. Bushell, A. Chaput, T. Oosterhoff. P. R. Le Sage, Convention Chairman, was absent because of illness.

MONTREAL—A "package" registration fee has been adopted for the Society's meeting here. The all-inclusive advance fee will be $30 for members and $40 for nonmembers, and their wives. The fee includes Official Luncheon, Paul Bunyan Hour, and ladies functions. Registration at meeting time will be $40 to members and $50 to nonmembers. One day registration, not including food functions, will be $6 and $7, respectively. **Note: Meeting Pre-registration blank on page 178.**

GENERAL

Monday, June 6, 8:45-12:30 p.m.

"FPRS Honorarium Lecture," Dr. A. J. Stamm, School of Forestry, North Carolina State College, Raleigh, N. C.; sponsored by the FPRS Midwest Section.

WOOD PRESERVATION

Monday, June 6, 2:00-4:30 p.m.

Program Chairman, R. H. Bescher, Assistant to Vice-President, Koppers Company, Inc., Pittsburgh 19, Pa.

"Methods of Specifying and Inspecting Marine Piles Used by the Lake Charles Port Authority," Monie Hudson, Spartanburg, South Carolina.

"Non-Destructive Method of Determining the Quality of Preservatives Extracted from tested Materials," S. W. Leach, Trafford, Pa.

"Improved Customer Acceptance of Poles Treated With Creosote-Pentachlorophenol Treated Solution," G. O. Lumsden, Timber Products Eng., Bell Tel. Labs., Inc. Murray Hill, N.J.

"Result-Type Specifications for Pentachlorophenol Treated Wood," H. A. Huber, Dow Chemical Co., Midland, Mich.

PACKAGING

Monday, June 6, 2:00-4:30 p.m.

Program Chairman, Karl Bollerslev, Boise Cascade Corp., Box 290, Boise, Idaho.

"And What of the Wood Box?," R. S. Kurtenacker, Engineer, USFPL, Madison.

"Problems Relative to Use of Container Board and Wood from Consumer Viewpoint," W. L. Newman, Mgr., Packaging Division, Services and Packaging Lab., General Electric Co., Schenectady, N. Y. and T. J. Luddy, NWBA, Washington.

"Packaging Design — Using Wood and Wood Products," Albert Kner, Design Engineer, Container Corp. of America.

CHEMICAL UTILIZATION

Monday, June 6, 2:00-4:30 p.m.

Program Chairman, F. G. Perry, Jr., A. D. Little Co., 30 Memorial Drive (Acorn Park), Cambridge, Mass., and Mrs. Claire Canty, A. D. Little Co.

WOOD COMPOSITION BOARD

Monday, June 6, 2:00-4:30 p.m.

Recorder, R. W. Young, Long-Bell Div. International Paper Co., Longview, Wash.

"Advantages of the End-Use Approach to Particle Board Standards," James Hamilton, Mich. College of Mining & Technology, Houghton, Mich.; and Dr. George Marra, Washington State Institute of Technology, Pullman, Wash.

"Advantages of the Properties Classification Approach to Particle Board Standards," Wayne Lewis, USFPL, Madison, Wis.; and Sigurd Johnson, N. C. State College.

Note: Meeting Pre-Registration Blank, Page 178

Wood Machining

Tuesday, June 7, 8:45-11:30 a.m.

Program Chairman, N. C. Franz, Univ. of Michigan, Ann Arbor. Presiding Chairman, C. P. Berolzheimer, Calif. Cedar Products Co., Stockton, Calif.

"Machinery Research," William McKenzie, Univ. of Michigan, (on leave from FPL, Melbourne, Australia)

"Stress Analysis in Circular Headsaws," G. W. Andrews and J. S. Johnston, FPLC, Ottawa.

"Russian Motion Picture on Machining," Richard Perkins, N. Y. State College of Forestry, Syracuse, N. Y.

"Appraisal of Foreign Activities in Wood Machining," Les Reineke, USFPL, Madison, Wis.

WOOD FINISHING

Tuesday, June 7, 8:45-11:30 a.m.

Program Chairman, N. C. Hatcher, Jr., Drexel Furniture Co., Drexel, N. C.

"Research on Wood Finishes," H. N. Johnston, Battelle Memorial Institute, Columbus, Ohio.

"Wood Finishes—How Good Are They?" J. A. Hager, Grand Rapids Varnish Corp., Grand Rapids, Mich.

"Production Finishing Problems," G. M. Hill, Drexel Furniture Company, Drexel, N. C.

CHEMICAL UTILIZATION

Tuesday, June 7, 8:45-11:30 a.m.

Program Chairman, F. G. Perry, Jr., A. D. Little Co., 30 Memorial Drive (Acorn Park), Cambridge, Mass., and Mrs. Claire Canty, A. D. Little Co., 30 Memorial Drive (Acorn Park), Cambridge, Mass.

GLUES & GLUING

Tuesday, June 7, 2:30-5:00 p.m.

Program Chairman, B. S. Bryant, Assoc. Prof., College of Forestry, Univ. of Washington, Seattle.

"Estimating Bond Quality in Plywood," Philip Northcott, FPLC, Vancouver.

"Contact Cements for Wood Gluing," R. F. Blomquist, USFPL, Madison, Wis.

"The Effect of the Wettability of Wood on the Glue Line Behavior of Two Urea Resin Adhesives," H. G. Freeman and F. F. Wangaard, Yale Univ. School of Forestry, New Haven, Conn.

"Types of Suitable Adhesives and Gluing Procedures for Fire-Retardant-Treated Wood," Leonard A. Ropella, Roddis Plywood Corp., Marshfield, Wis.

LUMBER MANUFACTURING

Tuesday, June 7, 2:30-5:00 p.m.

Program and Presiding Chairman, M. H. Mater, Mater Engineering, Corvallis, Ore. Recorder, Paul Heller, Mgr., Pacific Pine Lumber Co., New Westminster, B. C., Canada. Panel Moderator, Col. J. H. Jenkins, Director, FPL of Canada, Department of Northern Affairs and National Resources, Ottawa, Ontario, Canada.

"The Future of Hardwood Industry in Eastern Canada and Northeastern Canada," George French, Hay & Co., Ltd., Woodstock, Ontario, Canada.

"Economics of a Small Hardwood Sawmill," Don Cuppett, Forester, Union Carbide Chemicals Co., Charleston, W. Virginia.

"The Future of the Lumber Industry in Eastern Canada," Frank Rook, President, Pembroke Shook Mills, Pembroke, Ontario, Canada.

"Cost Reduction in Lumber Handling," J. R. Bemis, Ozan Lumber Co., Prescott, Ark.

MERCHANDISING

Tuesday, June 7, 2:30-5:00 p.m.

Program Chairman, Prof. William Lloyd, Dept. of Forestry, Michigan State Univ., East Lansing.

GLUES & GLUING

Wednesday, June 8, 8:30-11:30 a.m.

Program Chairman, Prof. B. S. Bryant, College of Forestry, Univ. of Washington, Seattle.

"Automating Glue Spreading and Lay-up," —Joint panel with Veneer and Plywood Division.

"Automating Possibilities," Henry Preusser, Technical Service Mgr., Adhesives, Resins, and Chemical Division, American Marietta Co., Seattle, Wash.

"Automating Possibilities with Dry Film Glue Line," R. K. Stensrud, Technical Div., Reichhold Chemicals, Inc., Seattle, Wash.

LOGGING

Wednesday, June 8, 8:30-11:30 a.m.

Program and Presiding Chairman, J. A. Doyle, FPL of Canada, Ottawa.

INDUSTRY-EDUCATION

Wednesday, June 8, 8:30-11:30 a.m.

Program Chairman, Dr. Everett Ellis, School of Natural Resources, Univ. of Michigan, Ann Arbor.

WOOD COMPOSITION BOARD

Thursday, June 9, 9:00-11:30 a.m.

Program Chairman, A. L. Mottet, Long–Bell Division, International Paper Co., Longview, Wash.

Presiding Chairman, J. R. Roberts, U. S. Gypsum Corporation, Palatine, Ill.

"Significance of Recent Developments in the Production and Use of Hardboard from the Mill Manager's Point of View," O. B. Eustis, Mgr., Hardboard Plant, Abitibi Corp., Alpena, Mich.

"Effect of Fiber Characteristics on Hardboard Properties," Dr. Dale Turner, Mgr. of Research, Masonite Corp., Laurel, Miss.

International Fibre Board Limited—Paper on insulating board.

"The Emerite Process of Hardwood and Semi-Hardboard Manufacture," S. Hunter W. Brooks, Miss.

"Insulating Board Markets and Uses," G. A. Goyder, International Fibre Bd., Ltd., Montreal, Quebec, Canada.

QUALITY CONTROL

Thursday, June 9, 9:00-11:30 a.m.

Program and Presiding Chairman, Dr. J. R. Stillinger, Technical Director, Cascades Plywood Corp., Lebanon, Ore.

"Work Sampling Method—In Application to the Logging Industry," Gilbert Tardif, Consultant to Operational Research Group, Quebec North Shore Paper Co., Quebec, Canada.

"Measurement of Machine Capabilities," Edward R. Hansen, Quality Control Statistician, Hamilton Mfg. Co., Two Rivers, Wis.

"Application of Linear Programming to a Sawmill Problem," Norman D. Jackson, Prof. of Forest Utilization, Univ. of West Va., Morgantown, W. Va.

"Effective Use of a Computer—A Case Study," B. C. Borden, Dist. Applied Service Rep., International Business Machines Co., Ltd., Toronto, Ont., Canada.

WOOD DRYING

Thursday, June 9, 9:00-11:30 a.m.

Program and Presiding Chairman, R. [illegible] Millett, Seasoning Research Division, FPL of Canada, Ottawa.

"The Moisture Content of Building Structural Members in Situ," W. C. Hopkins, Assoc. Prof. of Forestry, La. State Univ. College of Ag., Baton Rouge 3, La.

"Study of Lumber Drying & Quality Control of Moisture Content in Kiln Dried Lumber," Harvey H. Smith & John Dittman, P.O. Box 245, Berkeley, Calif.

Also: Informal discussion on research at FPLC, Ottawa, on kiln-drying of white pine as affected by chemical brown stain and moisture pockets.

WOOD COMPOSITION BOARD

Thursday, June 9, 2:00-4:30 p.m.

Program Chairman, A. L. Mottet, Long–Bell Division, International Paper Company, Longview, Wash.

Recorder, Dr. Dale Turner, Mgr. of Research, Masonite Corp., Laurel, Miss.

Presiding Chairman, Kjell Stordalen, Wynewood Products Corp., Jacksonville, Texas.

"Show-through of Particle Board Cores as Evaluated by a New Technique," Bruce Heebink, USFPL, Madison, Wis.

"Veneer Checking on Particle Board," Dr. M. M. Yan, Supervision, Panelboard Research, Abitibi Power & Paper Co., Sault Ste. Marie, Ont., Can.

"European Development of Particle Board Standards & Testing Methods," Dr. E. Plath, Mgr. Res. Inst. for Woodworking Materials & Wood Glues, Karlsruhe, Germany.

VENEER & PLYWOOD

Thursday, June 9, 2:00-4:30 p.m.

Program Chairman, J. L. Lutz, USFPL, Madison, Wis.

"New Plywood Uses Developed by Structural Research," David Countryman, Chief of Applied Research, DFPA, Tacoma, Wash.

"Commercial Standards for Hardwood Plywood Products," William Groah, Lab. and Inspec. Mgr., Hardwood Plywood Institute, Arlington, Va.

"Linear Programming in the Plywood Industry," Ernest Koenigsberg, Mgr. of Mgmnt. Sciences, Division of Touche Ross, Bailey & Smart, Certified Public Accountants.

Secretary Meets With Officers of Six FPRS Sections in Jan.-Feb.

As part of a program of strengthening the liaison between the national office in Madison and our officers in 14 Sections from coast to coast, Executive Secretary Frank Rovsek met, in late January and early February with officers of 6 midwest and far west sections.

Upper Mississippi Valley Section

A number of suggestions for improving service to our members and strengthening the Society were discussed. Meeting with the Officers of the Upper Mississippi Valley Section at Green Hall, School of Forestry, U. of Minnesota, in January, it was noted that membership here has grown from 83 in 1952 to 121 currently, 43 percent of which is concentrated in the Twin Cities. An intensive membership campaign under the direction of Leonard Ropella, the Roddis Corp., is being set up, in which he will be assisted in No. Wisconsin by Jim Bolon, in So. Minnesota by Walt Wallin, and in No. Minnesota by Bernie Granum. The Section also established its spring and fall meeting sites as April 28, 29 in Duluth, and October at St. Paul.

MIDWEST SECTION officers get together in Madison. L. to r. W. A. Gullickson, Don Lubeck, Chairman Bob Archambeault, Board Member Joe Allegretti, Jim Elf, Roy Newstedt, and Ken Kimball.

Midwest Section

The Secretary met with Regional Board member Joe Allegretti and officers of the Midwest Section on Feb. 4 in Madison. Don Lubeck, program chairman for the meeting on "Factory Finishing" held in Chicago last Fall analyzed some of the factors that resulted in its success. It was felt that at least one meeting per year should be developed around the practical production problems of the woodworking industry concentrated in this area. Joe Allegretti discussed the proposed national increase in individual dues, from $15 to $20 per year, starting in 1961. He emphasized that the majority of the funds would be used for publishing more information, in more pages, in the *JOURNAL*. As the Society grows, he said, more technology is becoming available that should be published for the benefit of the broad membership. Finally, the officers voted to hold the fall meeting in Madison, in cooperation with the U.S. Forest Products Laboratory and in conjunction with "National Forest Products Week," during Oct. 16–22.

PACIFIC NORTHWEST officers and committee members met at Bellingham. That's past-chairman Phil Northcott in the center.

REGISTRATION, at Bellingham, reached almost 150. Ed Clarke, new chairman, is at left.

BANQUET SPEAKER was Robert Seidl, Director of Research, Simpson Timber Co., who related his experiences in Russia.

Pacific Northwest Section

On February 7, 8 the Secretary visited with officers and members of the Pacific Northwest section at Bellingham, where a program on plywood technology attracted an estimated 150 persons. Regional Board Member Tony Veazey addressed the dinner audience briefly on the subject of FPRS national needs, centering principally about the need for an increase in dues in order to step-up our publications effort. Section Chairman Phil Northcott described the work of the Industry–Education Sub-Committee, headed by Prof. Bill West, and its efforts to acquaint high schools in the northwest with opportunities for graduates in the wood industry and in advanced education for the forest products industry. The Section, to date has purchased and distributed more than 1,500 copies of the NALM–FPRS "Careers Opportunities" booklet. Plans were set for two forthcoming meetings, May 9, 10 at Eugene, Ore., and again in Oct. at Tacoma.

TONY VEAZY, left, Northwest Regional board member and national membership chairman reports to group.

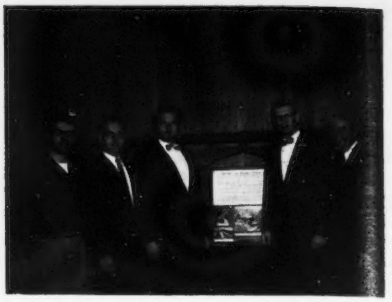
SOME OF SPEAKERS and panelists on the subject of plywood.

PART OF GROUP enroute on second day for tour of Bellingham Shipyards and Puget Sound Pulp and Timber sulfite mill.

BELL-BUOY BOAT CO. was a highlight of plant tours on first day.

Following his visit at Bellingham, Secretary Rovsek during the remainder of the week made contacts with advertising clients and agencies in Seattle and Portland. Of particular interest was a call on FPRS members Lionel Pease and Jim Wells of Mill Equipment Co. and then to the rebuilt Barbee Lumber Mill at Kennydale, Washington, a good example of a modern, automated mill.

NO. CALIFORNIA officers and committeemen met at the U. of California with President-Elect Ray Berry and the Executive Secretary.



QUICK VISIT to California Forest Products Lab provided opportunity to renew friendships with Director Fred Dickinson and various staff members. Also present, Ray Rietz, of Madison F.P.L., enroute to Orient.

Meets with Acting President Berry

In San Francisco the Secretary met with Acting President Ray Berry on the important subject of getting the proposed NLMA–FPRS vocational and professional "Careers Opportunities Unlimited" program into operation from coast to coast. Mr. Berry is in the process of establishing a national committee of six persons, not presently on the Executive Board, to head the program from a regional standpoint, working directly with officers in the 14 sections.

Northern California Section

On Feb. 16, the Secretary met with Regional Board member Fred Dickinson and officers of the Northern California Section at Berkley, Calif. The set-up of the national membership program was discussed, and also the question of the need for an increase in dues. The Section discussed its spring and fall meetings, to be held at San Francsico and Stockton. A visitor to the meeting was Jack Berry (no relation to Ray Berry) chairman of the International "Hoo-Hoo Forest Products Week" observation later this year. He expressed his appreciation for the support which FPRS sections have given this project to date.

SOUTHWEST officers met with Secy. at Los Angeles: Fred Card, guest Bob Reason, Secy. Joe Miller, Vice Chairman, Curt Hay, and affable chairman Ole Anderson.

Pacific Southwest Section

On Feb. 19, Rovsek met with the officers of the Pacific Southwest Section at Los Angeles. A stimulating discussion was held on the merits of planning very practical vs. fundamental research-type meetings for the wood industry of the area, without any firm conclusions being drawn. In a unique presentation, the Section is going to feature several motion pictures from the U.S. Forest Products Laboratory, Madison, at its March 16 meeting. Later, in May, the Section has invited Ray Berry to address it on a report of progress of the Society.

Rocky Mountain Section

The Secretary's final stop was Feb. 19th at the meeting of the youngest section, the Rocky Mountain, at Fort Collins, Colo. Here, before some 50 members and guests, he discussed the actions and goals of the Executive Board, and arranged with Chairman Bob Bader to assist on a personalized membership program. Further contact with the officers will be had early in April when the special policy committee of the Board meets in Denver.

Upper Mississippi to Meet in Duluth, Minn. in April

The Upper Mississippi Valley section is planning a two-day (including transportation to and from one's place of business) meeting in Duluth. April 28 and 29. The program will center about visits to, and technology of "Reconstituted Wood Products Plants—and Utilization." A number of wood composition board plants and other unique operations will be visited by pre-arranged bus tours.

The entire program will start the afternoon of the first day, continue through with a banquet and informal discussions in the evening, and wind up with interesting plant tours the fore-noon of the second day—all in time for FPRS members to be home by Friday evening.

National Forest Products Week Set for Oct. 16–22

Plans for the first National Forest Products Week, conceived and sponsored by Hoo-Hoo and Wood & Wood Products Magazine, and endorsed by the National Wood Council, have been announced by Jack S. Berry, Chairman, Hoo-Hoo Wood Promotion Committee, Sacramento, and FPRS member.

The week is planned as a vehicle for all who play a part in the forest industries, from lumber and wood products manufacturers through to Christmas tree merchants. It will also encompass tree farmers, foresters, researchers and suppliers. Two circulars, "National Forest Products Week" and "Plan for Action," giving details may be obtained from Jack Berry, Hoo-Hoo International Wood Promotion Committee, 1507 21st St., Sacramento, Calif.

Pacific Northwest Meets May 9, 10 at Eugene, Oregon

The Pacific Northwest Section will meet at the Eugene Hotel, Eugene Oregon for its Spring meeting. Local arrangements are under the direction of Paul Walsh; and program under Ed Clarke. A tentative technical session is planned on "Paints and Finishes."

Pacific Northwest Elects

Officers elected at the February meeting of the Pacific Northwest Section at Bellingham, Washington for the term 1960–61 include: Chiarman, W. R. Francis, Shelton, Wash.; Vice-Chairman, E. H. Clark, U.S. Forest Service; Secretary, Don Burnet, Crown–Zellerbach Corp.; Treasurer; R. W. Petterson, St. Paul & Tacoma Lumber Co.; Trustees, A. Bonutto, Monsanto Chemical Co. and E. H. Williston, Weyerhaeuser Timber Co.

Inland Empire Meets In Spokane, April 13

F.P.R.S. Inland Empire Section will have a technical session and business meeting on April 13 at the Davenport Hotel in Spokane. This is part of the Annual N.W. Wood Products Clinic sponsored by the Spokane Chamber of Commerce on April 12–13. The FPRS program is as follows:

9:00 A.M.—Working Stresses for Douglas-Fir—A Progress Report, by George Hjort, V. P., Boise Cascade Corporation, Boise, Idaho.

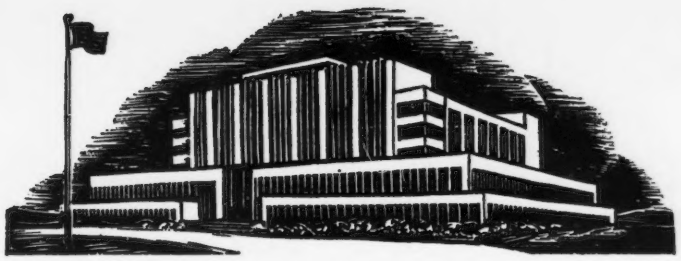
9:30 A.M.—Wind Forces in Building Design—A Digest, by E. S. Kotok, Chief U.S. Forest Utilization Service, Ogden, Utah.

10:00 A.M.—Coffee break.

10:15 A.M.—The Development of New Aluminum Building Materials, by Grant T. Facer, Manager, Product Planning and Development, Building Materials Division, Kaiser Aluminum & Chemical Corporation, Oakland, California.

10:45 A.M.—The Use of Finger Joints in Structural Lumber, by Bernie Welch, Research Engineer, Western Pine Association, Portland, Oregon.

11:15 A.M.—Inland Empire Section Business Meeting.



USFPL Celebrates 50th Anniversary, June 2–4

The Fiftieth Anniversary of the U. S. Forest Products Laboratory, oldest research organization of its kind in the world, will be observed June 2–4 at Madison, Wis.

The 3-day affair, Director Edward G. Locke said, will begin with a banquet Thursday evening, June 2. At a general meeting Friday morning, key leaders in industry, government, and education will speak on various facets of research, past and future; and in the afternoon they will view special exhibits and witness dedicatory ceremonies. All day Saturday, the staff will hold open house.

The Laboratory was dedicated June 4, 1910, to a career of public service that has yielded rich returns to both producers' and consumers' wood products. High among its achievements are such advances as: New pulping processes for "weed" species; Basic discoveries that helped launch house-prefabrication and timber-laminating industries; Kiln drying and other wood seasoning processes; Preservatives and processes used to immunize huge quantities of wood against decay and fire; Packaging research that has reduced shipping costs and losses during peace and war.

The Laboratory's half-century span, Dr. Locke points out, coincides with the world's emergence from "the horse-and-buggy age into the age of rockets." The Laboratory's research program has been likewise transformed, contributing not only "better seasoned wood for wheelwrights but more dependable nitrocellulose propellants for space vehicles," he emphasized.

Special exhibits at the Golden Anniversary celebration are planned to demonstrate the progress of Laboratory research from its beginnings to the present. Examples of both fundamental and applied research will be illustrated.

One of the benefits that it is hoped will result from the June gathering, the director said, is a broad assessment and reappraisal of forest products research goals.

"Scientists," he commented, "are not in the habit of looking backward. An occasion such as this, though, gives us unusual reason to reflect upon what has been done and what needs doing. We are inviting our friends from other laboratories, from industry, and from the schools and colleges to join with us in such reflections and exchanges of viewpoints."

Dr. Locke extended a special invitation to FPRS members to visit the Laboratory on their way to the National Meeting in Montreal.

For persons wishing to travel from Madison to Montreal, TransCanada Airlines offers three direct flights from Chicago to the Canadian city. Two of these leave Chicago's Midway airport at 1:40 and 3:45 p.m., arriving at Montreal's Domestic Terminal at 6:30 and 8:10 p.m., respectively. The third flight leaves Chicago's O'Hare Field at 4 p. m., arriving at Montreal at 8:40 p.m. There is excellent air service from Madison to Chicago via Northwest Orient or North Central Airlines.

Rail transportation is available from Chicago to Montreal via Canadian National Railways, which has a daily train leaving the Dearborn Street Station at 10:50 p.m. and arriving in Montreal the following day at 10:30 p.m.; connection with that train is afforded by a Milwaukee Road train leaving Madison at 5:05 p.m. and arriving at Union Station at 8 p.m.

Soviet Lags Behind U.S. in Wood Production

Forests of the U.S.S.R. cover some 2,827,000,000 acres compared to 784,000,000 in U.S. Most of Russian forests are softwoods, and its hardwood stands are much less than U.S., both in extent and diversity of species. In output, Russia produced 34 billion board feet of lumber in 1958 compared to U.S.' 40 billion board-feet. These are among facts reported by Dr. Geo. Garratt in Southern Lumberman, Jan. 1, and reprinted in Hardwood Forestry Bulletin.

Wood Office Furniture Sales

Wood office furniture sales during 1959 climbed to a record of $83.2 million, a 21.8 percent increase over 1958, according to figures released by the Wood Office Furniture Institute, Robert Spelman, Executive Director.

1959 Lumber Production

With an unusual December upturn, national lumber production in 1959 totaled 36,934,000,000 board feet, 9 percent over 1958 and the highest since 1956.

Candidates for FPRS National Offices Announced

Candidates for the national executive board have been announced by Dr. Frank H. Kaufert, chairman of the 1960–61 National nominating committee.

Raymond H. Berry, current president-elect will automatically become president in June, succeeding Dr. E. S. Harrar, who becomes past-president.

The committee's candidate for the office of president-elect is Donald K. Saunders of Westbrook, Maine, current vice-president. Its candidate for vice-president is T. S. Veazey, Jr., Butte, Montana, currently Northwest regional board member.

F. H. Kaufert, chairman of the National nominating committee, has announced candidates for the 1961–62 National nominating committee as follows: D. G. Lubeck, Chicago, Illinois; S. B. Preston, Ann Arbor, Michigan; William C. Hopkins, Baton Rouge, Louisiana; W. L. Lear, Crossett, Arkansas; Frederick F. Wangaard, New Haven, Connecticut; P. L. Northcott, Vancouver, B. C.; R. H. Ripley, Tacoma, Washington; Harold Moser, Louisville, Kentucky.

Fifth World Forestry Congress, August 29-September 10

Secretary of State, Christian A. Herter, in welcoming the congress to the U.S., says, "We believe that this Congress will advance the science and practice of forestry in its broadest concepts by providing an opportunity for the exchange of information and the development of personal associations between leaders and technicians on an international basis."

Open to all interested persons, it will be held at the University of Washington, August 29 to Sept. 10th. Inquires should be directed to I. T. Haig, Office of International Conferences, Dept. State, Washington 25, D.C.

Syracuse Offers Summer Research Grants to Qualified Teachers

A select number of qualified teachers in colleges and institutes will receive financial grants for the opportunity of gaining specialized research experience this summer at State College of Forestry, Syracuse. The grants are made possible by the National Science Foundation, Washington, D.C. The program is especially designed to provide research opportunities to qualified teachers from institutions having few research facilities or programs. Participants will receive stipends of $75 per week, weekly allowance of $15 per dependent, plus nominal transportation allowance, for the 10-week program, June 20–August 27. For details write Dr. E. C. Jahn, Director of Research, State University College Forestry, Syracuse University, Syracuse 10, N.Y.

Candidates for Northwest Regional Board Members

Robert J. Seidl, director of research, Simpson Timber Co., Seattle, and Edward M. Williston, manager, Lumber & Plywood Development Dept., Weyerhaeuser Co., Longview, Washington, have been named as candidates for the three-year post of Northwest regional board member, succeeding T. S. Veazey, according to John D. Ritchie, Douglas Fir Plywood Association, chairman of the nominating committee.

Research News from Forest Products Labs of Canada

Cut-Off Saw Horsepower Requirements

One of the problems facing the small sawmill owner is obtaining exact information on power requirements for various types of mill equipment. The Ottawa Laboratory is presently engaged in determining power requirements for auxiliary equipment such as edgers and cut-off saws.

Preliminary studies have recently been completed on a pendulum type 20 inches daimeter cut-off saw with the standard peg tooth. Power requirements were determined for both white spruce and white pine in thicknesses varying from 1 inch to 4 inches and for feed speeds varying from 33 to 72 feet per minute. Studies of this nature will be continued for the various commercial saw-log species in Eastern Canada and complete results will be released as soon as available.

Adhesives For Dielectric Heating

An extensive study recently carried out at the Ottawa Laboratory on the dielectric properties of synthetic resin adhesives indicated considerable variation in the suitability of various adhesives for use with dielectric heating. Thirty-one adhesives of the urea, resorcinol, phenol, phenol-resorcinol, and melamine resin types were studied.

Results indicated a wide variation in the electrical properties of these materials with variation in conductivity for adhesives of one type ranging from approximately 500 to 3500 micromhos. The conductivity of an adhesive is an indication of its efficiency when used with a dielectric heating process. Detailed results of this study are given in **F.P.L. Technical Note No. 4,** which is available on request.

Bark Utilization

Recent work carried out at the Ottawa Laboratory has shown possibilities of producing fiberboard and particle board from the readily available barks of certain pulpwood species. Bark studies presented under way are aimed at chemical utilization of some bark fractions for the production of adhesives, which might find application in the production of particle board.

Working Stresses

In structural applications of sawn timber that require an engineered design, the designer must have the allowable working stresses of the species that will be used in the structure. The strength properties most commonly required in design are fiber stress, longitudinal shear and modulus of elasticity in bending, and compression perpendicular to and paralled to the grain.

Stress grading rules, of which Ganadian Standards Association Specification 043 is an example, regulate the degree and location of permissible defects for a particular end use and stress level without regard to species. The working stresses applicable to lumber graded according to these rules may be found in C.S.A. Specification 086. Many Canadian species are grade as yard lumber. This yard lumber may still be assigned safe working stresses providing the grading rules are known. Provision for doing so is also given in C.S.A. Specification 086.

Recent FPLC Publications

The following publications are available on request from either the Ottawa or Vancouver Laboratory, Forest Products Laboratories of Canada, Forestry Branch, Department of Northern Affairs and National Resources, Canada.

Semi-annual Report—April–September 1959.

Loss in stiffness evaluates decay resistance of wood treated with copper naphthenate. J. W. Roff and H. Shen.

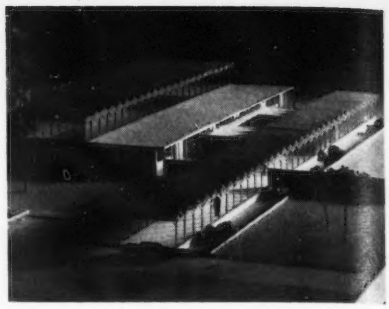
Sonic detection of blisters—for plywood and other bonded materials. D. G. Miller.

Spruce and Balsam bark as a source of fibre products. F. Bender.

La Scie Principale—Comment en obtenir le meilleur rendement. G. W. Andrews.

Mimeo V–1026—The characteristics and significance of Spruce. K. G. Fensom.

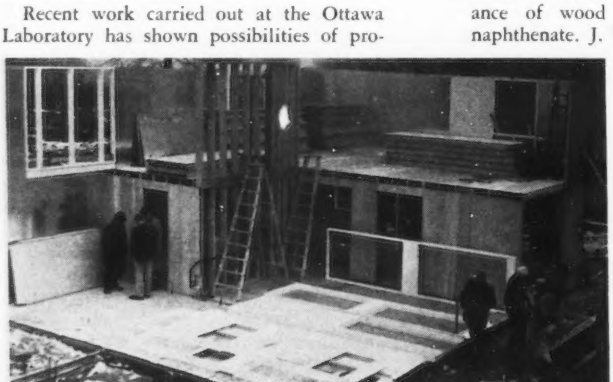
Bulletin III—The Kiln-Drying of B. C. Lumber.

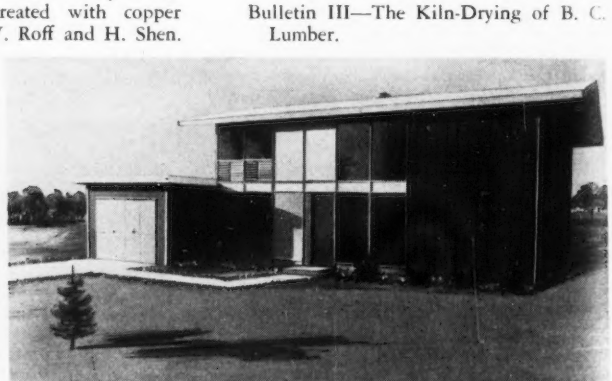


New Research Laboratory For Simpson Timber Co.

Simpson Timber Co. will break ground this spring for a new forest products research and development laboratory on a ten-acre tract in Overlake Park near Bellevue, Wash. Plans call for the new facility to be in operation late next fall, according to C. H. Kreienbaum, Simpson vice-chairman.

R. J. Seidl, Simpson research director, reported the laboratory will serve 21 production plants extending from Everett, Wash. to central California. To meet the varied needs of these operations, it will be staffed and equipped to conduct experiments on all phases of forest products of present or potential interest. Initial staff will consist of 40 scientists and technicians.





1959 NAHB Research House Features Foam Core Panel Construction

Chicago, Ill., January 15—A new milestone in the search for more modern methods of homebuilding, which will lead to better homes at lower cost to both builder and homebuyer, was reached with the completion of the two-story 1959 NAHB Research House in East Lansing, Michigan. A cooperative venture of the NAHB Research Institute and the Residential Building Curriculum of Michigan State University, this new home was designed and developed by the NAHB Research Institute.

This house features many innovations and new products, including the extensive use of stressed skin modular panels. These panels, manufactured by Koppers Company, Inc., at its new panel plant in Detroit, Michigan, offer remarkable opportunities to the builder and architect for flexibility in design and construction.

Foam Core Panels

The panels feature a foam core made of expandable polystyrene molded between interior and exterior structural building materials, to form a durable, attractive, and lightweight "sandwich".

The exceptional strength of these panels exceeds the standards established by the HHFA for load-bearing walls of conventional construction. Their remarkable lightness also permits ease and speed of handling, which will reduce construction cost.

Effectiveness of the insulating qualities of the foam core in these panels has been proved through its use as an insulating medium for modern refrigerators and freezers. In the panels, this solid foam core offers a closed cell type of insulation that will not sag or pack with the passing of time, nor be affected by moisture.

What's New in *Technical Publications*

USFPL Publications

Single Copies of the Following Reports are Available Free Upon Request from the Director, U.S. Forest Products Laboratory, Madison 5, Wis.

Another in its series of technical reports on foreign woods, entitled **Mahoganies**, is one of three new research reports recently published by the U. S. Forest Products Laboratory. The report, No. 2167, describes the physical and mechanical properties of true Central and South American mahogany along with some other characteristics of this long-popular wood.

Another publication, **Determining Preservative Retention in Piling by the Assay of Borings,** Report No. 2172, describes a method of checking the amount of preservative retained in various kinds of wood piling to evaluate the quality of treatment.

The results of groundwood pulping experiments are presented in **Report No. 2175, "Groundwood Pulping of White Fir and Corkbark Fir,"** along with a summary of the use of these pulps in papermaking.

Insulation Board Publications

Two new publications, "Fundamentals of Building Insulation," a 12-page semi-technical guide, and "Painting Insulation Board," a how-to-do-it manual, are made available to FPRS members according to Robert A. LaCrosse, Technical Director, Insulation Board Institute. Up to three copies of each are available free; others may be bought for 40¢ and 5¢ respectively. Write 111 W. Washington St., Chicago 2, Ill.

AITC Timber Treating Standard

Section 1100 Treating Standard has been approved to be added to the "Timber Construction Standards" promulgated by the American Institute of Timber Construction, according to Frank J. Hanrahan, Exec. V.P. The standard indicates conditions under which treatment of wood is advisable, and when unnecessary. It covers types of treatment, preservatives and recommended minimum retentions for sawn and laminated members. Single copies of the standard are available free from AITC, 1757 K St., W. Washington 6, D. C.

New "Where To Buy" Directory

The 1960 edition of the West Coast Lumbermen's Association Directory is available. The 52-page book lists 250 sawmills in the Douglas-fir region. Each mill's listing includes address, personnel, capacity and species. Forty different mfg. items are listed across top of each page, easily cross referenced. Copies are free from WCLA, 410 S.W. Morrison St., Portland 5, Ore.

Literature Available

Timber Standards

AITC—Sa 11.06, Selection of Adhesives; and, Section 900, Guide Specifications for Structural Timbers were recently revised. AITC–Sa 11.02, Camber and Deflection—Glued Laminated Beams, has been reprinted and is available for distribution. Single copies available without charge from American Institute of Timber Construction, 1757 K Street, N. W., Washington, D. C.

West Coast Lumber

The new booklets, "Where to Use Utility Grade West Coast Lumber," and "Grade Stamps for West Coast Lumber," have just been released. Copies are available from: West Coast Lumbermen's Assoc. 1410 S. W. Morrison St., Portland 5, Oreg.

Wood Preservative

Reichhold Chemicals, Inc., recently issued a new bulletin that gives information on the advantages, applications, physical properties, and specifications of pentachlorophenol. Write to Reichhold Chemicals, Inc., RCI Bldg., White Plains, N. Y.

Tree Farm Guide

The Western Pine Assoc. has published a new booklet "Forest Practice Rules and Oregon Tree Farm Guide." The 52-page handbook applies to species on industrial forest lands and tree farms in Eastern Oregon. It gives "how-to-do-it information" on crusing timber, scaling and grading, thinning and pruning, fire and insect protection, and dozens of other phases of the tree growing business.

EDITOR'S NOTE

Corrected reprints of **"Circular Sawing Experiments on a Radial Arm Saw,"** by C. W. McMillin and J. L. Lubkin are now available. When published in October, four curves were transposed, and the December correction was not complete.

The article described tests to determine power required to saw certain species under a variety of conditions. For flat-sawn maple, it was shown that a single power formula can encompass effects of depth of cut, feed rate, and cutting direction.

Reprints are available from: American Machine & Foundry Co., Central Research Laboratory, 200 North Henry St., Stamford, Conn.

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FOREST PRODUCTS RESEARCH SOCIETY
417 North Walnut Street
Madison 5, Wisconsin

NAMES in the NEWS

John H. Hinman, Chairman of the Board, International Paper Co., New York, and president of American Forest Products Industries, has been presented a Golden Anniversary Award from the Boy Scouts of America for his "Significant service to American boyhood through scouting." Presentation to Mr. Hinman was made by **Charles A. Gillett,** Washington, D.C., managing director of AFPI. Under Mr. Hinman's leadership, AFPI conducts the Boy Scout Conservation Award of Merit program and a number of other youth forest activities throughout the U.S.

Raymond C. Rietz, nationally-recognized wood seasoning expert at the U.S. Forest Products Laboratory left, in mid-February, on a round-the-world trip to gather information that will further develop and strengthen seasoning research at the Lab. He will confer with authorities in Australia, Tasmania, the Philippines, Japan, India, Italy, Germany and England. He will return to the U.S. about April 20.

Clarence F. Van Epps has been named director of purchase analysis at Stromberg Carlson, Rochester, N. Y. In this new position he will be responsible for assisting the operating divisions in reducing material costs. "Van" is a past Regional Board member of FPRS.

EMPLOYMENT Opportunities

Inquiries concerning employment listings or ads to be placed in the JOURNAL should be addressed to FPRS Employment Service, P. O. Box 2010, University Station, Madison 5, Wis. Correspondence is kept confidential.

Positions Offered

E-365—Two wood technologists and one nonprofessional research aide. Responsibilities in products and materials testing, wood structure research, and mechanical wood technology. MS or BS plus one year's experience required for wood technologists. Previous experience in timber mechanics will be given fair consideration. No specific requirements for research aide. Request application forms from Director, Forest Products, Oregon Forest Research Center, P. O. Box 571, Corvallis, Oregon. Describe background, experience, and schooling. (Mar.)

E-378—Leading coated abrasives manufacturer has challenging opening for chemical engineer or equivalent with experience in coated abrasives application in furniture manufacture, allied woodworking fields. Both plant and field sales engineering, calling on woodworking manufacturers. $6500 to $7000 to start. Opportunity for advancement. (March)

E-379—Engineer. Under direct supervision of manager, development plant, or group leader, assist in development of preservatives and uses for treated forest products involving new or improved methods, treating processes. Receive project assignments, outline procedure for development, secure approval, and proceed with development work. Must be a chemical engineer or wood utilization graduate. (March)

E-380—Wood Technologist wanted to work on gluing problems in Douglas-fir plywood industry. Laboratory and field technical service work involved. (March)

E-381—Midwest company interested in individuals with training and experience in the engineering of wood products. One, a man capable of designing and engineering the day-to-day design of products and services for the home builders; another to lead new product development, exploring new ways in which wood products can be used in home building. (March)

E-382—Industrial engineer with strong background in woodworking industry wanted by nation-wide service organization. Applicants with degrees in wood technolgy and experiences or training in electrical or mechanical engineering will be considered. Some travel required. (March)

E-384—Technical director to be responsible for new Collins Pine Company flakeboard quality control and devolpment laboratory at Chester, California. Ability to formulate and administer quality control, process and product development programs necessary. Wood technology degree required and experience in flakeboard or particle board laboratory and/or production desired. (April)

E-385—Quality piano manufacturer located in New York City wants wood technologist to train as assistant superintendent. Shop experience in furniture or piano work desirable. Applicant should be familiar with gluing techniques, laminating, wood-working machinery, etc. (April)

Employment Wanted

591—Superintendent: 34 years of age, married, ind. eng. background, 10 years' experience in yard, kiln, machining, methods, finishing, product development, design, quality and cost control. Desires position as superintendent of plant with 300 or more employees. (March)

595—University of Michigan wood technology graduate, holds degree of Forest-Engineer from European University. Presently holds supervisory position in wood working firm, seeks production, quality control, or managerial position in wood working industry. Age 33; married. (April)

598—Assistant manager plywood operation available June. Experience, training (M.) totals 18 years, incl. R & D, admin., sales, some production. Objective top management. Age 39. Resume on request. (Apr.)

599—Production management in fields of plywood and particle board, and sales promotion in same fields. BS in forest products and management; Minor in Accounting. Six years' experience quality control and industrial engineering in plywood and veneer. Married. Located on West Coast. Would consider opportunity in Northeast or on the East Coast. (April)

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FPRS FOREST PRODUCTS JOURNAL VOL. X. NO. 3 MARCH, 1960

A PHOTOGRAPHIC STUDY OF Veneer Formation

LAWRENCE LENEY
Assistant Professor, University of Missouri, Columbia, Missouri

Quality of veneer depends on what happens at the edge of the knife. Here is a fundamental study of the cutting action. Structural deformation and types of failure were analyzed under magnification and thru motion pictures of the cutting action.

Fig. 4.—Cutting cottonwood test blocks (1) 21° knife, (2) experimental nosebar, (3) vise to hold block securely, (4) rear support plate to simulate additional wood as exists in veneer bolt.

THE QUALTY OF VENEER IS largely the result of what happens at the edge of the veneer knife. Additional research is needed to promoted a better understanding of this brief but very important stage in the manufacture of veneers and plywood. The treatment of the flitch or bolt, the strength and surface quality of the veneer, and the glueline strength in the finished plywood are dependent upon the way the wood is deformed in the cutting process.

Veneer cutting has been an art acquired by experience. Yet, in recent years, some excellent research has been undertaken to establish methods and techniques on a more scientific basis. A number of studies have been done on a pilot plant or commercial scale to determine the settings of knife angles and nosebar openings for cutting stronger, smoother veneer. The relationship of the depth and frequency of lathe checks to the temperature and strength properties of the wood have been determined by closely controlled small-scale laboratory tests on wood samples of reduced size (7)[4] Theoretical considerations have been given to the probable forces involved in the veneer cutting process (7, 9). The effect of cutting forces on the wood has been measured for cuts made in the veneer direction without a nosebar (4). The cutting angles used, however, were less than 60 degrees as used in wood machining. There appears to be no such study for cutting angles of more than 60 degrees as used in veneer production.

The orthogonal cutting techniques developed for the study of chip formation in metal cutting (1, 8) have been successfully applied to the study of chip formation in wood when the cut is parallel to the grain, as in the planing operation (3). Still, there is little in the literature concerning the changes that take place in the wood structure at the edge of a veneer knife.

Objectives and Scope

This paper is a partial report of a larger study designed to determine, at least in part, what happens at the edge of a knife cutting in the veneer direction. The general approach to this research was to observe the deformation of the cellular structure of the wood with a microscope during the cut, and to measure the force components parallel and normal to the cutting plane.

Only certain observations of the deformation of the wood structure, as recorded by the motion picture camera, will be discussed at this time. The objective is to show how cutting geometry and the structural properties of the wood affect the veneer.

As the structure of wood allows large plastic strains, it precludes the strict application of the theory of elasticity in the analysis of results. However, by noting and measuring the strains and the method of failure visible on the cross section of the test blocks, some conclusions have been reached on the general stress pattern.

Definitions

The lack of standard terminology to describe cutting geometry suggests the need for the following definitions to prevent confusion. The illustrations in Figures 1 and 2 have been rotated 90 degrees from the usual orientation so they will correspond with the pictures

[1] Contribution from the Missouri Agr. Exp. Sta., Columbia, Mo. Journal Series No. 2113. Presented at Session II, Veneer and Plywood, FPRS 13th National Meeting, June 28–July 3, 1959, in San Francisco.

The Author: Professor Leney received BS and MS degrees from New York State University, College of Forestry, Syracuse, and he is now a candidate for Ph.D. at that University.

[2] A preliminary report of doctorial research in the Department of Wood Products Engineering, State University College of Forestry, Syracuse, N. Y., done with the assistance of the National Science Foundation.

[3] A 20-minute motion picture based on this study is available on loan from Visual Education Department, 23 Jesse Hall, University of Missouri, Columbia, Mo., for a mailing and maintenance fee of $1.00.

[4] Numbers in parentheses refer to Literature Cited at the end of this paper.

of the cutting action used in this report. The nosebar shown is an experimental design.

- α primary cutting angle
- α' secondary cutting angle
- β primary sharpness angle
- β' grinding angle, angle of ground bevel
- γ primary clearance angle
- γ' secondary clearance angle
- ω_f face honing angle
- ω_b back honing angle
- θ nosebar compression angle
- ϕ nosebar clearance angle
- k knife angle as used in commercial practice (90 degrees plus the clearance angle)
- t_1 depth of cut; undeformed veneer thickness
- t_2 actual veneer thickness
- h horizontal nosebar opening
- v vertical nosebar opening

Face of the knife[3]: the surface in contact with the veneer.

Back of the knife: the ground bevel side next to the workpiece, flitch or veneer bolt.

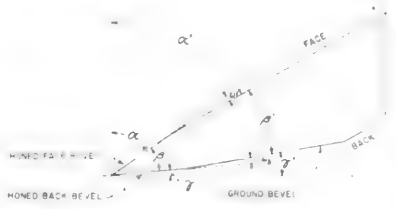


Fig. 1.—Knife angles and surfaces.

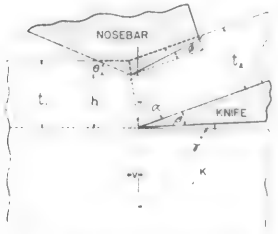


Fig. 2.—Geometrical relationships in the orthogonal cutting of veneer.

Procedure

Test blocks of cottonwood, *Populus deltoides* Bartr., silver maple, *Acer saccharinum* L., and sugar pine, *Pinus lambertiana* Dougl. were fed against a stationary knife of known angle by using a milling machine as shown in Figures 3 and 4. In this method, defined as "orthogonal cutting" (8), a straight edge knife with a plane surface is set with the cutting edge perpendicular to the straight line direction of relative motion of knife and block to generate a surface parallel to the original plane surface produced by the previous cut. As the cutting deformation takes place in a very short distance, orthogonal cutting closely approximates the conditions of the rotary cutting process. However, it does not truly represent the slicing process where the wood travels in a straight line which is not perpendicular to the knife.

[3] It should be noted that the term "face" and "back" of the knife are reversed from that familiar to some. The usage here is in agreement with most fundamental studies of cutting.

Fig. 3.—General view of equipment for taking motion pictures of the cutting process.

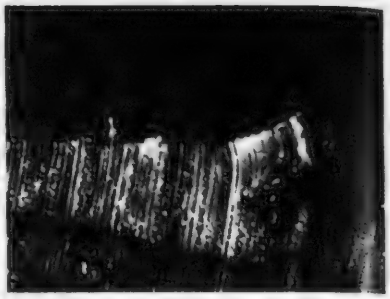


Fig. 5.—A small depth of cut in sugar pine showing the deformation to be essentially the same as in thicker cuts. (t = 0.02 in., $\alpha = 64°$, $\beta = 25°$, $\gamma =$, knife = sharp.)

The rectangular test blocks were cut so the surfaces were at right angles or parallel to the grain. They measured 1 or ½ inch longitudinal to the grain, 1-⅛ inches in the cutting direction, and approximately 1-½ inches perpendicular to cutting plane.

The block was clamped in a special holder to assure a rigid condition. Only ¼ inch was allowed to project above the top of the holder. The holder was then clamped to a strain gage dynamometer which was capable of measuring the force on the wood block workpiece during the cut. The force vectors parallel and normal to the cutting plane were recorded by a two-pen oscillograph with appropriate strain gage amplifiers.

The cutting velocity used was 2.54 inches per minute with the few exceptions where 1.27 inches per minute was used. During the cut, the deformation of the cells as viewed on the cross section surface was observed through a stereoscopic microscope of 9X or 27X magnification. To see the cells clearly, the cross section face of the test block was surfaced in a sliding microtome. Motion pictures of the action were taken at 64 frames per second. A specially mounted monocular microscope with a 32 millimeter or 48 millimeter microtessar lens, without an eyepiece, was used as the lens system (Fig. 3). This gave a magnification of 2.5X and 5X on 16 millimeter film. At these magnifications, the width of the frame on the projection screen shows either 4 millimeters or 2 millimeters of the wood.

The woods were tested at a moisture content above the fiber saturation point. Maple and cottonwood were obtained in the green condition. The sugar pine was carefully chosen air-dry stock that was soaked to return it to essentially the green condition. All tests were run with the wood in equilibrium with the room temperature, maintained between 75° and 80°.

Knives with sharpness angles between 15 and 35 degrees were tested, using a clearance angle of zero to 10 minutes. This gave cutting angles nominally between 55 and 75 degrees. All angles were measured to the nearest 5 minutes. All knives were carefully ground and honed to standardize the effect of sharpness. To aid in standardization, the effect of sharpness was studied, but for the sake of brevity it will not be discussed in detail.

A nosebar was not used in most of the study. The intention was to first determine the basic type of deformation caused by the knife as it passed through the wood, and to determine how the failure took place in the formation of the veneer chip. The nosebar was then applied to observe how it changed this basic cutting action to reduce the wood failures which result in poor quality veneer.

The nosebar was used with a horizontal opening of 0.05 inches for all tests. The vertical opening was varied between 0.01 and 0.03 inches. by using veneer thicknesses of 0.055, 0.06, and 0.07 inches, the direct compression of the nosebar was 0.005, 0.01, and 0.02 inches, respectively. Based upon the undeformed veneer thickness, this is approximately 9, 17, and 29 percent nosebar compression.

Although the thickness of cut was not over 1/16 inches for the most part, the range included veneer thin enough to be free of failure and thick enough for the formation of lathe checks.

Observations and Discussion

Veneer Classification: The observations made in this study show that it is difficult to classify veneer by type based upon the particular kind

wood failure that occurs at or ahead of the cutting edge. When attempting such a classification, as used in earlier cutting studies (3, 7), it is evident that there are not only failure types, but also combinations of these failures, depending upon the wood properties and cutting geometry. Therefore, in this discussion it seems advisable to define a basic *continuous* veneer and then to consider the types and combinations of failure.

Continuous Veneer Formation: Continuous veneer will be considered to be an unbroken sheet of wood in which the original wood structure is essentially unchanged by the cutting process. Without a nosebar, this can be accomplished by using a sharp knife and a small thickness of cut as shown in Figure 5. The only failure in such a cut is the continual separation of the cells at the cutting edge. This produces relatively smooth unbroken surfaces on both sides of the cut.

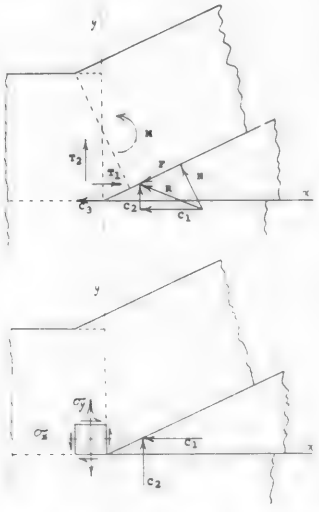


Fig. 7—The stress components considered to be acting at the edge of the knife.

The deformation of the wood structure during the formation of continuous veneer is illustrated by Figure 6. This is a series of enlargements made from a motion picture which recorded the start of a cut in green cottonwood. As the cells in the cutting plane are severed or separated by the cutting edge, those just above must change direction if they are to move up the face of the knife. This relative movement perpendicular to the cutting plane is resisted by wood structure above. The cells at the face of the knife are compressed (Fig. 6A). The compression increases rapidly causing frictional resistance as these cells move up the knife and away from the cutting edge. When the distance from the cutting edge is great enough, a point of maximum pressure is reached. Further increase is relieved by the bending of the veneer. This cantilever beam action produces a maximum moment over the cutting edge (Figs. 6B to 6D). The rotation of the wood structure causes a visible compression strain on the top or *face* of the veneer, and a less evident but measurable tension strain on the knife side or *back* of the veneer. Figures 6A and 6D illustrate this point. In both pictures, the numbered lines pass through the same points of the wood anatomy. The change of distance between lines for the two stages of the cut indicate the areas of tension and compression parallel to the surface of the veneer.

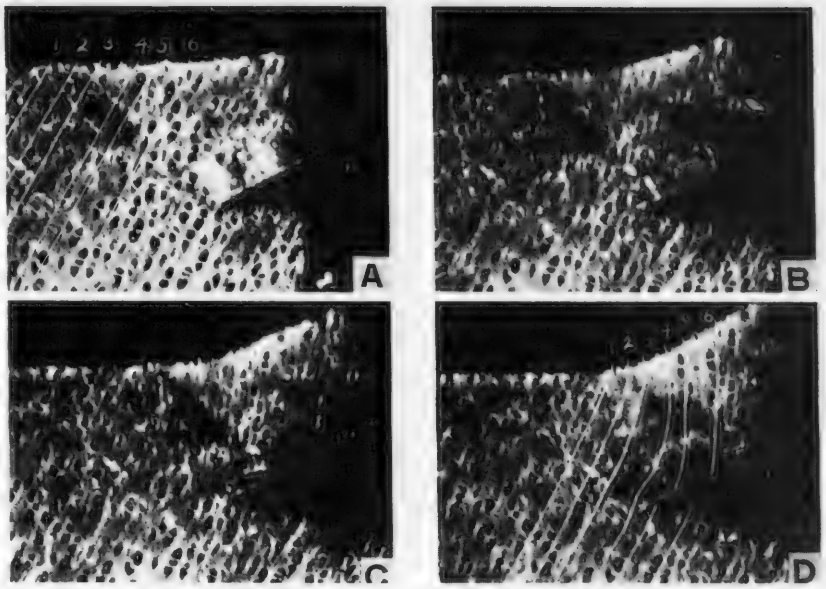


Fig. 6.—The start of a cut in cottonwood. The lines drawn on (A) and (D) show the same points in the wood structure for the two stages of the cut. ($t_1 = 0.05$ in., $\alpha = 64°$, $\beta = 25°$, $\gamma = 1°$.)

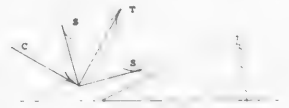
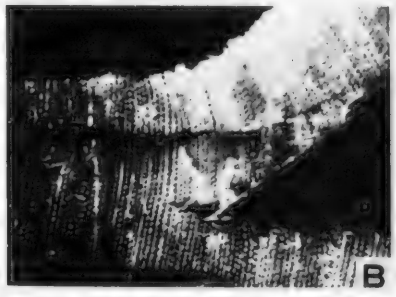


Fig. 8.—A qualitative stress pattern showing the general direction of principal stresses determined by study of the motion pictures.

Figures 9A and 10 illustrate the reduction of strain achieved by grinding the knife to a minimum angle to increase the cutting angle. One of the practical considerations that limits the reduction of the grinding angle is the quality of the sharpening equipment and its proper use to prevent the removal of temper at the cutting edge. Another consideration is the strength of the knife edge needed for the type of wood being cut. In these experiments, it was difficult to produce a satisfactory cutting edge at a sharpness angle of 15 degrees. Frequently the edge was easily bent over to create



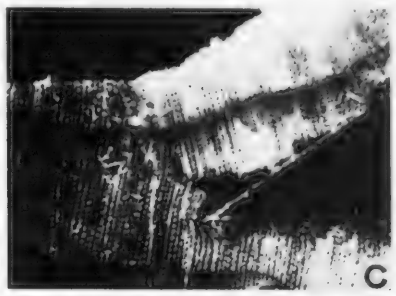


Fig. 9.—Formation of lathe check in sugar pine. ($\alpha = 54° 20'$, $\beta = 35° 10'$, $\gamma = 30'$, $t_1 = 0.05$ in.) A. Immediately before the check starts. B. Initial Failure. C. Tension failure forms perpendicular to cutting plane due to cantilever beam action.

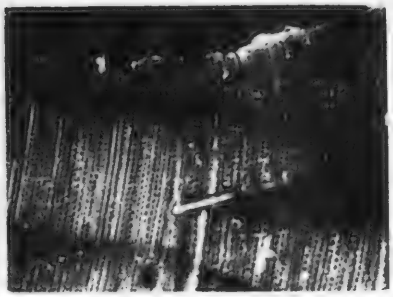


Fig. 10.—Reduction of deformation by using low angle knife in sugar pine. (α = 74° 30′, β = 15°, γ = 30′, t_1 = 0.05 in.)

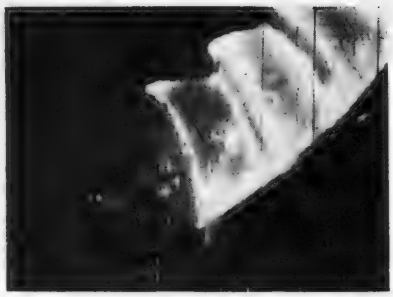


Fig. 11.—Shear failure in paraffin similar to that observed in metal cutting. (α = 54° 20′, β = 35° 10′, γ = 30′, t_1 = 0.05 in.)

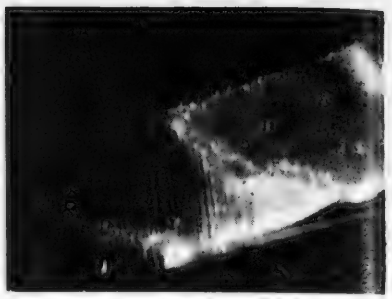


Fig. 12.—Failure in paraffin which approximates the pattern of lathe check formation in wood. (α = 74° 30′, β = 1[illegible], γ = 30′, t_1 = 0.05 in.)

a condition far worse than that caused by a knife dulled by the wearing away of metal.

To provide a sturdier edge while still maintaining a 75 degree cutting angle, the microsharpening technique was investigated (5).

A knife was ground and honed to 15 degrees β' in the regular manner. Then, by tilting the stone at 10 degrees to the surface, ω_b, a back bevel[6] 0.2 millimeter wide was formed. This produced a sharpness angle β of 25 degrees at the cutting edge. To maintain close control of the angle and to prevent oversharpening, a slow-cutting Arkansas stone was used with a jig.

This sharpening method resulted in a cutting edge that produced a veneer surface of exceptional smoothness. The slight negative clearance angle in this knife setting caused a compression under the edge of the knife. This appeared to aid the cutting action, and it warrants further investigation.

Stresses at the Edge of the Knife: Based upon studies of the motion pictures of the cutting action, the stress components believed to be acting in the vicinity of the cutting edge are summarized diagramatically in Figure 7. The compression N, normal to the face of the knife, produces friction F, which resists the movement of the veneer up the knife. The resultant compression R can be resolved into components C_1 and C_2 acting in the direction of the x and y axes. The tension stress T_3, produce by the moment M, is opposed by the compressive stress C_3. As the wood is not severed ahead of the cutting edge, compressive stress C_2 produces tension stress T_2. The compression C_3, which acts in the cutting plane immediately ahead of the cutting edge, is considered to be the severance force. The magnitude of these stress components depends upon the strength of the wood, veneer thickness, cutting angle, knife sharpness, and the frictional resistance at the face of the knife.

It is evident in Figure 7A that a point at or just above the cutting edge is in a shear-stress field due to the abrupt change of stresses. The resulting shear stresses that appear to exist in the xy plane are shown in Figure 7B as acting on the sides of an elementary parallelepiped. The normal stress σ_y is equal to the tension T_2. As the normal stress σ_x is equal to the difference between T_3 and C_3, it may be either compression or tension depending upon the conditions of the cut as they effect the relative value of T_3 and C_3. For a point directly in front of the cutting edge σ_x is compressive due to C_3.

If, for the above mentioned qualitative shear pattern, σ_x is less than σ_y. The maximum tension stress can be expected to be more than 45 degrees but less than 90 degrees to the cutting plane. This agrees with the general direction of principal stresses shown in Figure 8, as estimated from the study of the motion pictures. Maximum tension T is considered to act perpendicular to the maximum compression (minimum tension) C, and 45 degrees to the maximum shear stresses S. This stress pattern indicates why the initial tension failure in the formation of lathe checks was observed to occur at an angle to the cutting plane rather than parallel to it.

Lathe Checks: When paraffin was cut with the knife set at cutting angles of 55 and 75 degrees, two somewhat different types of failure occur, as shown in Figures 11 and 12. Besides the continual severance of the paraffin at the cutting edge, the stresses which deform the chip for the 55 degree cutting angle, produce a periodic shear failure, as shown in Figure 11. As found in the study of metal cutting (1), the chip moves in the direction indicated by the arrow. At a cutting angle of 75 degrees (Fig. 12), the relative movement of the chip in respect to the workpiece is opposite to that shown in Figure 11. There is some question whether the failure in Figure 12 is clearly one of shear or of tension failure followed by shear movement.

For the same range of the cutting angles, the woods tested showed no evidence of typical shear, as shown in Figure 11. The point of interest is the similarity in the development of the failure of paraffin (Fig. 12), and that observed during the formation of lathe checks during the cutting of wood veneer. Most of the lathe checks were considered to be tension failure due to the direction in which the rupture

[6] This "back bevel" is on the side of the knife next to the work-piece. There was no "face bevel" produced on the veneer side.

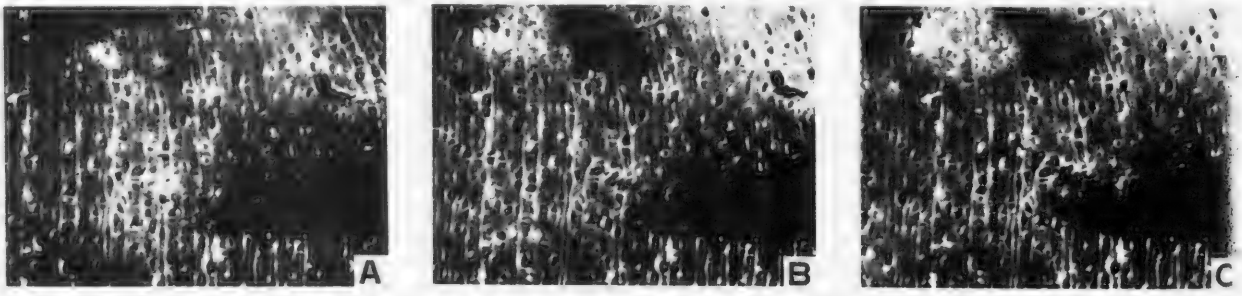


Fig. 13.—Start of check in cottonwood. The bubble indicates location of compression. α = 65°, β = 15° 46′, γ = 9° 15′, t_1 = 0.08 in.

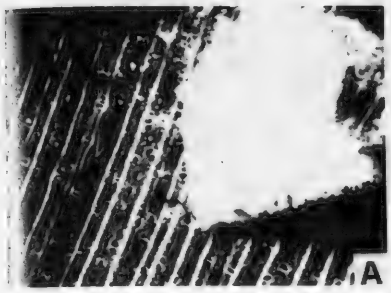
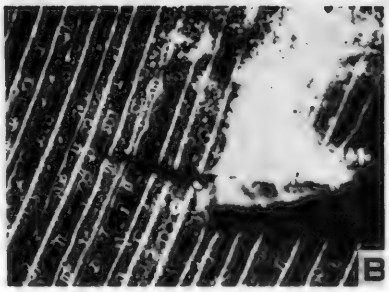
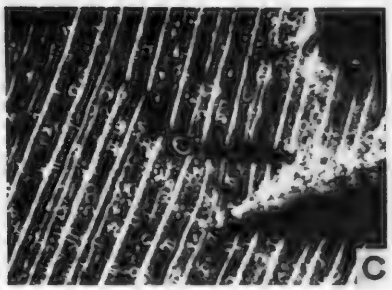


Fig. 14.—Start of check in silver maple. Depth of cut, t_1, is 1.25 in. Change in bubble formation indicates change in compression behind the cutting edge. The knife was microsharpened as follows: $\alpha = 74°$ 30′, $\beta = 25°$, $\beta' = 15°$, $\gamma = -9°$ 30′, $\gamma' = 30'$, $\omega_b = 10°$, width of honed bevel = 0.2 mm, no honed front bevel.





opened. However, there was some indication of possible shear, as shown in Figure 13. This was observed in cottonwood when the check opened slowly in a position above or behind the cutting edge. The initial break is circled by a dash line in Figure 13A. The check then opens slowly as it passes over and behind the cutting edge (Figs. 13B and 13C). As observed in paraffin, there is some question whether this can be defined as shear failure or tension failure followed by shear movement.

For the more typical lathe check formation, a short failure opens quickly, as shown in Figs. 9 and 14. This start of the lathe check is usually at an angle to the cutting plane, and it gives the appearance of being a tension break.

For hardwoods, after the initial rupture, the knife continues in the cut and the direction of the line of failure gradually curves upward until it approaches a direction normal to the cutting plane. This is similar to the check shown for paraffin in Figure 12. This direction of curvature was also shown in pictures taken by Fleischer (2). Figure 14 shows the change of direction of a check formed in silver maple when cutting at a 1/8-inch thickness without a nosebar.

Check formation in conifers differs somewhat from that observed in hardwoods. The initial failure continues in a fairly straight line for a greater distance. Then with a sudden change of direction the failure approaches a normal angle to the cutting plane. As shown in Figure 9C, the rupture usually follows a ray. Test cuts at a greater thickness showed the same tendency of abrupt change of direction to form an irregular curve in a stepwise or zig-zag pattern rather than the more continual curve observed in the porous woods.

The change of direction of the lathe check is attributed to a change in the magnitude of the components of force contributing to the resultant maximum tensile stress. As the rupture develops, the decrease of compression C_2 immediately behind the cutting edge, will reduce T_2. At the same time, T_1 will tend to increase due to the reduction of C_1 and the increase of the lever arm producing moment M. This change of stresses causes the rotation of the resultant maximum tensile stress, which increasingly acts in a direction more parallel to the cutting plane as the lathe check enlarges.

Compression Tearing: In the more compressible and weaker springwood of cottonwood and sugar pine, there is less tendency for lathe checks to form. Unless the knife is sharp, however, considerable damage to the surface of the veneer will be caused by *compression tearing*, as shown in Figure 15. In sugar pine, even with the sharpest knife, this failure occurs occasionally. When such flexible wood structures are cut, the cells in front of the cutting edge are under reduced tension perpendicular to the cutting plane. This lessens their tendency to fail when contacted by the cutting edge. Instead of failing, the cells conform to the shape of the knife edge and resist severance by the reduction of stress concentration. As a result, the cells are compressed ahead of the knife until sufficient force is developed for severance to take place. This compression produces a tension above and below the cutting plane such that rupture usually starts at approximately 45 degrees to the cutting plane (Figs. 15, 16A, 17, and 18). As the rupture enlarges, it follows a curved path to approach a direction parallel to the cutting plane. This results in a bundle of cells being pulled out of the veneer surface. Whether the surface condition appears rough and broken or just wooly depends upon the depth to which this compression tearing develops. In thick veneer, the rough condition is usually associated with checks.

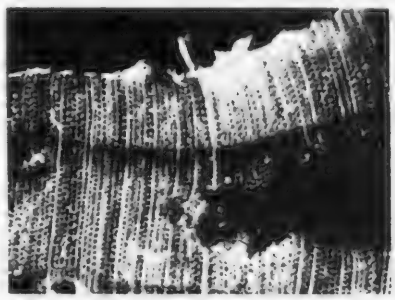


Fig. 15.—Compression tearing in sugar pine due to dull knife. ($\alpha = 64°$, $\beta = 25°$, $\gamma = 1°$, $t_1 = 0.05$ in).

There is a definite relationship between the occurrence of lathe checks

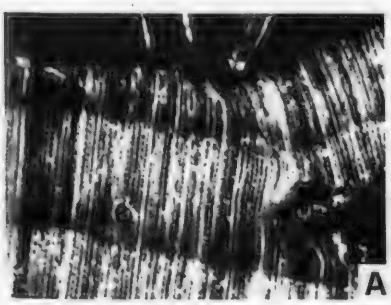
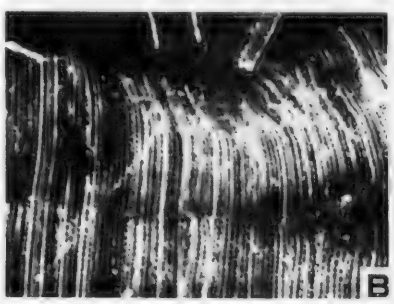
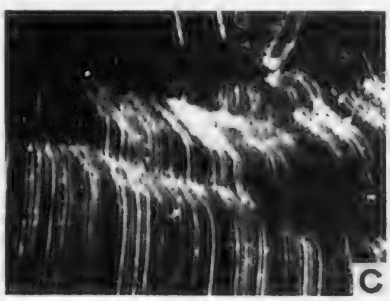


Fig. 16.—Nosebar action when cutting sugar pine. ($\alpha = 68°$, $\beta = 21°$, $\gamma = 1°$, $r = 0.01$ in., $h = 0.05$ in.) Thickness, t_1, was varied to change the amount of nosebar compression: (A), $t_1 = 0.055$ in.; compression = 9 percent; (B), $t_1 = 0.06$ in.; compression = 17 percent; (C), $t_1 = 0.07$ in.; compression = 29 percent.





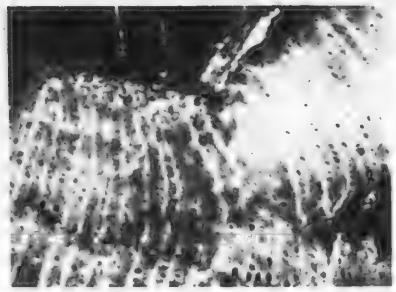


Fig. 17.—Failure under the knife caused by overcompression in maple: $\alpha = 68°$, $\beta = 21°$, $\gamma = 1°$, V = 0.03 in.; h = 0.05 in., t_1 = 0.07 in., compression = 29 percent.

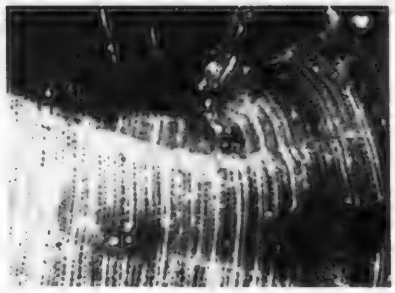


Fig. 18.—Stresses due to sudden release of pressure behind the nosebar. Compression tearing is evident at knife edge: $\alpha = 68°$. $\beta = 21°$, $\gamma = 1°$, V = 0.02 in., h = 0.05 in. compression = 17 percent.

and compression tearing, depending upon the sharpness of the knife and the mechanical properties of the wood. Following the initial formation of a lathe check as shown in Figure 9B, the knife in effect starts into a very small depth of cut. If severance at the cutting edge continues uninterrupted, the check will close up and be unnoticeable when the cutting stresses are relieved. However, the cells in the cutting plane are not supported by wood structure above. This lack of tension perpendicular to the cutting plane makes severance difficult. As a result, compression tearing readily develops concurrently with the lathe check, as shown in Figure 9C.

Lathe checks account for the loss of veneer strength in tension perpendicular to the grain (6). Compression tearing determines the roughness of the veneer surface.

Nosebar: There is a general belief that the nosebar reduces the formation of lathe checks by direct compression of the wood between itself and the knife. This appears to be only part of the action. Figure 16 shows a stepwise increase in compression of sugar pine by varying the veneer thickness while keeping the horizontal nosebar opening at a constant 0.05 inch. There is a pronounced compression parallel to the cutting plane in front of the nosebar. If the nosebar is properly placed, this *precompression* assists the rotation of the wood structure above the cutting edge. This lowers the neutral axis, to reduce the tension stress acting parallel to the back of the veneer. When cutting greater thicknesses, the precompression is not sufficiently effective in depth to prevent the start of lathe checks, but it will reduce the depth.

In attempting to prevent lathe checks, increased nosebar pressure beyond a critical point will produce overcompression, as shown in Figure 16C. This permanent deformation of the wood structure can be seen to reduce the thickness of the veneer as evidenced by the crooked ray structure.

Another defect resulting from overcompression is shown in Figure 17. The combined force of the nosebar and the knife edge parallel to the cutting plane causes tension failure under the knife edge. The checks are formed in the face of the veneer yet to be cut.

The conventional solid nosebar allows a sudden release of pressure behind the point of maximum compression, as shown in Figure 18. This results in a shearing action which causes failures on the face of the veneer. In some cases, these checks may have been started by the compression tearing at the knife during the previous cut. The sudden release of pressure behind the nosebar tends to open such failures and enlarge them. This increases veneer roughness.

To prevent tearing due to the sudden release of compression as described above, an experimental double-surfaced nosebar, based on the work of Voskresenskij (9), was tested, as shown in Figures 2 and 4. The cutting action is illustrated in Figure 19. Initially, the back surface of the nosebar was set parallel to the face of the knife. The distance between the nosebar and knife when measured perpendicular to the face of the knife was the same as the horizontal opening *h*. A high resistance to movement of the veneer was observed even at relatively low nosebar compressions. This resulted in a failure below the knife edge similar to that shown in Figure 17. A slight evidence of this failure is present in Figure 19. To reduce the resistance to veneer movement, without changing the horizontal or vertical opening, a clearance angle, ϕ, (Fig. 2) of approximately four degrees was used. This allowed a gradual release of compression with very satisfactory results.

Besides controlling the release of compression, the pressure of the back surface of the double-surfaced nosebar assists the rotation of the wood structure. This, in combination with an increase of friction between the veneer and the knife face, reduces the tension strain evident on the back of the veneer. The added frictional force allows a lower percentage of nosebar compression than would be needed with a conventional nosebar.

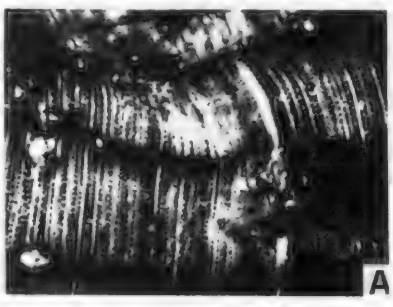
The main disadvantage of the double-surfaced nosebar is the precision required in its adjustment. From what has been said, it can be seen that the angle and the distance between the knife and the back surface of the bar are critical.

Although the tests with the double-surfaced nosebar were limited in scope, the results indicate there is sufficient added control of the veneer cutting process to justify investigation.

Summary of Conclusions

The veneer cutting process can be best described by first defining the formation of a continuous veneer. Further description is based upon the type of wood failure or combinations of failures that occur under various conditions of wood properties and cutting geometry. The two major types of failure are lathe checks and compression tearing.

Although possible shear failure was observed, most lathe checks appear to be tension failures resulting from a combination of stress components that depend upon properties of the wood, veneer thickness, cutting angle, knife sharpness, and friction between the veneer and the face of the knife. The resultant maximum tensile stress at the knife edge is not necessarily perpendicular to the cutting plane. This is



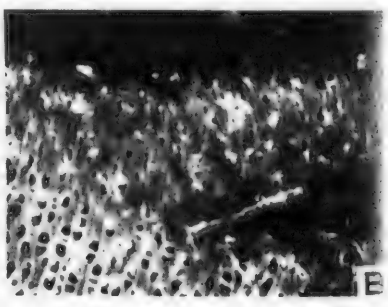


Fig. 19.—Double-surface nosebar: $\alpha = 68°$, $\beta = 21°$, $\gamma = 1°$, V = 0.01 in., h = 0.053 in., t_1 = 0.058 in. (A), sugar pine; (B), cottonwood.

evidenced by lathe checks that usually start to form at an angle to the cutting plane and follow a curved path until they approach a perpendicular direction. The change of direction results from a change in the stress components during the check formation.

Compression tearing results from resistance to severance at the cutting edge, causing groups of cells to be pulled out of the veneer surface. Formed alone or in combination with lathe checks, compression tearing is the direct cause of veneer roughness or woolly surfaces. The development of this type of failure depends on knife sharpness and the physical properties of the wood being cut. Normal nosebar pressures cannot be expected to eliminate this source of defect.

By increasing the cutting angle, stresses that cause lathe checks can be reduced. Microsharpening proved to be an effective method of maintaining a sturdy cutting edge when the cutting angle is increased.

The nosebar assists in the reduction of the tension stresses that cause lathe checks by precompressing the wood parallel to the veneer surface, and rotating the wood structure over the cutting edge. Under certain conditions, failures in the face of the veneer may be caused or accentuated by the action of the nosebar. A double-surfaced nosebar was found to give added control over the cutting action.

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Lathe Check Formation In Douglas-fir Veneer[1]

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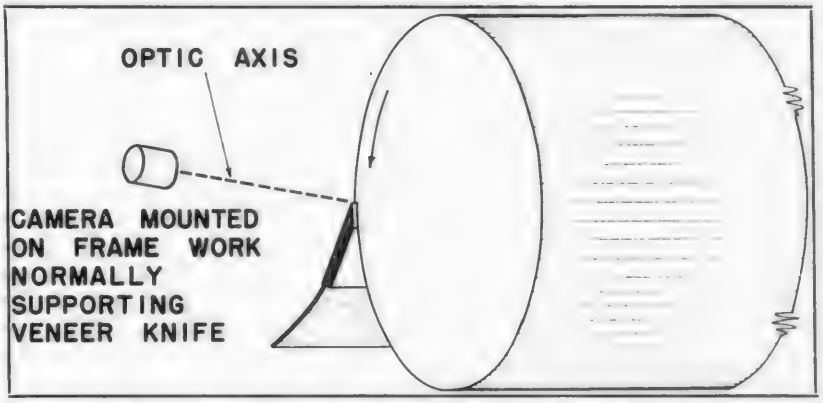

Fig. 1.—The camera "looked" closely along the nosebar at the veneer cutting process visible at the end of the log. About 1 inch of the knife protruded beyond the log towards the camera.

High-speed motion pictures of veneer cutting with a roller-bar production lathe were analyzed to determine the effect of production variables, such as nosebar pressure and cutting speed, on veneer smoothness and depth of lathe cuts.

THIS PAPER PRESENTS AN ANALYSIS of high-speed motion pictures of veneer cutting on a roller-bar production lathe.[2] After the log was placed in the lathe it was pushed to one end of the opening as far as the spindles would allow. A section of the lathe knife was removed at the open end, and a Wollensak high-speed camera was mounted on a bracket and clamped where the portion of the knife had been removed. The camera "looked" closely along the nosebar at the veneer cutting process visible at the end of the log, with about one inch of the knife protruding beyond the log in the direction of the camera (Fig. 1). The high-speed pictures showed a wide variety of space and time details under quasi production conditions.

Experimental Design

The experimental design consisted of pictures and veneer sampling for the following conditions: (a) low pressure, standard speed, (b) standard pressure, standard speed, (c) standard pressure, high speed, and (d) high pressure, standard speed. The term "standard" refers to conditions the production lathe operator would use if he were peeling the log in regular production. Low pressure is that ordinarily used for Douglas-fir sapwood, while high pressure and high speed are greater than standard. Because of the small amount of sapwood present on the selected log, only condition (a) was observed for the sapwood. Because much additional information can be obtained from measurements on the veneer, however, two repetitions of the conditions listed were made, and samples of veneer

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[1] Presented at Session II—Veneer and Plywood, FPRS 13th National Meeting in San Francisco, June 28–July 3, 1959.

[2] The U.S. Forest Products Laboratory, Madison, Wisconsin has available a similar film of veneer cutting with a solid compression bar. Conditions with a roller-bar were considered sufficiently different to justify investigation.

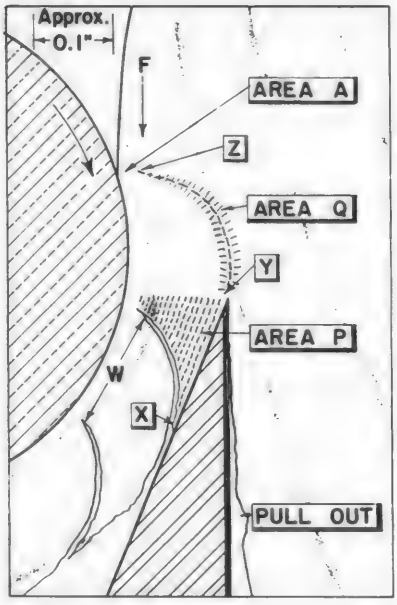

Fig. 2.—Diagram of the veneer cutting process observed in high-speed motion pictures.

were taken, but the high-speed pictures were omitted. Observations on this veneer substantiated the conclusions reached from a study of the film.

The camera had a built-in timing device that made exposures on the edge of the film by means of a neon light flashing at 60 cycles per second. A scale factor was established by means of a reel of pictures taken of graph paper (10 lines per inch) fastened to the stationary log. Power measurements were taken under cutting conditions and with the log turning freely. The samples of veneer for the conditions listed were measured for the percentage of depth of lathe checks and their frequency (checks per inch) by the DFPA method.[3] Veneer smoothness criteria were obtained in arbitrary units by using equipment developed at the Technical Center of the Weyerhaeuser Company, in which the pressure required to force air under the edges of a weighted plastic cup is measured. The thicknesses of the veneer samples were measured with a micrometer having a 4- by 8-inch mandrel.

Results

The veneer cutting process, as indicated by the high-speed camera pictures, produced veneer of basically a Type A pattern.[4] There were many and varied changes of detail, however, depending upon variations in density, slope of grain, etc. in the wood and upon cutting conditions such as nosebar pressure, cutting speed, and horizontal and vertical openings.

Figure 2 presents an "averaged" view of the cutting of Douglas-fir sapwood under standard conditions of low pressure and average speed at the instant before the next lathe check, indicated by the dotted line, is formed. As the wood advances against the knife through the distance XY, the area P is believed to be compressed, and a stabilized cutting condition exists in which the knife advances at a uniform rate. Although the magnification was not sufficient to observe fiber behavior, it was conjectured that the fibers break in tension parallel to the direction of cut. The area Q is stressed in tension normal to the knife-cut at the start of the check. As soon as rupture occurs, an unstable condition exists, and the lathe check advances very rapidly (snap action). The lathe check is stopped because of decreased displacement and because the stress F/A becomes very great. Supporting this explanation is evidence obtained from the veneer: (a) regardless of applied pressure there is always a sharp edge at Y; and (b), "pull out" sometimes exists on the log side.

The pictures showed that, as the nosebar pressure is increased, the thickness "t" between the nosebar and knife decreases, and the proportion of the distance XY to the width W generally increases. The ratio of distance XY to W is in the range of 80 to 90 per cent, except where "pull-out" occurs, which may drop the ratio to the 50 per cent range. Increasing the speed of cutting causes a redistribution of the applied force F, with less force on the nosebar and more on the knife. The ratio of the cutting distance XY to W is apparently greater for high-speed cutting, which results in a slightly smoother veneer. Examination of the veneer resulting from high-pressure cutting showed shallower and more numerous lathe checks and a permanent cell compression in the springwood.

Numerical data pertaining to the cutting conditions for each of the five rolls of film taken are shown in Table 1. As required, the projected images of the frames were examined and measured by means of a divid and scale and a film editor (an optic device for film examination).

Table 1.—SUMMARY OF DATA PERTAINING TO VENEER CUTTING UNDER CONDITIONS OF HIGH SPEED MOTION PICTURES

	Low Pressure, Standard Speed; Sap	Low Pressure, Standard Speed; Heart	Medium Pressure, Standard Speed; Heart	Medium Pressure, High Speed; Heart	High Pressure, Standard Speed; Heart
Velocity of Cutting, ft./min.	272	264	316	572	418
Force on nosebar and knife (Pounds per inch of knife)	25	23	45	73	87
Distance between lathe checks on films, mils— Equivalent frequency ( )	206(5)	140(7)	145(7)	132(8)	107(9)
Frequency of lathe checks estimated from veneer (no. per in.)	7	7	9	10	12
Cutting thickness, nosebar to knife, from film (mils)	130	136	118	128	110
Veneer thickness, from veneer samples (mils)	138	140	114	123	120

To compute the data in the fir two rows, use was made of the sca factor, power measurements, and th number of frames per second in th portion of the film where measur ments were made. The distance b tween lathe checks, as measured the film, was generally greater th the value computed from the fr quency of lathe checks observed on th veneer. This may be accounted for b compression of the veneer as it passe through the throat between the nos bar and knife, and by the fact th only larger and more prominent lath checks were measured on the film The lathe was set to advance 0.13 inch per revolution; thickness measur ments on the veneer were made whil the veneer was still wet. The thickness data show that increasing the applied pressure reduces the thickness, a relationship that is well known.

Conclusions

Examination and analysis of the veneer and of the pictures taken with the high-speed camera suggested a number of conclusions.

1. A modified Type A veneer is produced by cutting at a steady rate for much of the distance between lathe checks.
2. A lathe check is produced by an unstable "snap action" in an area stressed under tension normal to the break. At the start the stress is nearly normal to the cut, but it rapidly changes to a direction nearly parallel to the cut.
3. In the range of the cutting speeds investigated (250 to 600 fee per min.), increasing the speed produced a veneer with a slight improvement in smoothness.
4. High pressure applied to the nosebar produced a smoother veneer with shallower and more numerous lathe checks and with compression damage to the springwood structure.

[3] Thomas E. Batey, Jr., 1955. Douglas Fir Plywood Association, Laboratory Bulletin 55C. Technique of Rendering Lathe Checks Clearly Visible.

[4] McMillan, Charles W., 1958 Forest Products Journal VIII (1):23–32. The relation of the mechanical properties of wood and nosebar pressure in the production of veneer. (This paper contains an excellent bibliography).

A NEW DEVICE FOR STUDYING

The Blister Resistance of House Paints

Fig. 4.—View of FPL blister box showing test panels installed.

Fig. 5.—Forest Products Laboratory blister box modified to simulate wetting of wood siding by rain.

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Forest Products Laboratory,[2] Forest Service, U. S. Department of Agriculture

A new paint blister box simulates cold-weather condensation and rain penetration in house siding. Results are close to actual conditions in real houses, thus paints and water repellents can be compared on a realistic basis.

ONE OF THE MORE SERIOUS FORMS of failure of paint on houses is blistering and peeling. There are at least three distinctly different kinds of blistering: (1) temperature blistering, (2) chemical or "glossy-back" blistering, and (3) moisture blistering. Although they share certain basic characteristics in common, namely, (a) a softening and swelling of the paint, (b) a weakening of adhesion between paint and wood or between layers of paint, and (c) a fluid (gas or liquid) pressure under the blisters, the conditions under which these characteristics are brought about differ greatly. Of the three, moisture blistering is by far the most widely prevalent and is therefore the kind with which this paper is concerned.

In moisture blistering the softening and swelling and the weakening of adhesion are caused by the action of water on the paint. Water is undoubtedly involved also in production of the fluid pressure but the mechanism that builds up the pressure is as yet not completely determined. A number of theories have been suggested, as yet without confirmation. Probably no one theory will account for all cases of moisture blistering. Fundamental studies of the mechanism of blistering are in progress at the Forest Products Laboratory. Meantime, empirical methods of testing paints for sensitivity to moisture blistering are needed and perhaps will continue to be even after basic theory has been established.

The first successful device for studying moisture blistering of paints on wood was made approximately 30 years ago but was not published until 1933 (2).[3] It was a 14-inch cubical box provided with openings on the four vertical sides to hold wood specimens or panels painted on the outside face. The air within the box was heated by electric light bulbs and humidified by means of an open pan of water placed over the bulbs. At first, provision was made for alternate periods of heating and cooling, but it was soon found that results nearly as satisfactory were obtainable with steady maintenance of a temperature gradient through the walls, with the inside at the higher temperature.

The device was designed to study the discoloration of paint by the aqueous extracts from redwood and redcedar. It was soon found that some paints discolor easily but may resist blistering, whereas other paints blister readily but may resist discoloration until aqueous extract bursts through the blisters. Subsequently the device served chiefly to study paint blistering.

The earliest tests followed the convenient course of using the temperature of the laboratory (say 75° F.) for the outside or "cold" side of the box and raising the temperature inside to 130° F. or thereabouts. Concern was soon felt lest results under such abnormal conditions might be unrepresenta-

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[1] Presented by D. F. Laughnan at the Eleventh Annual FPRS Meeting in Buffalo, N. Y., June 1957; received at the JOURNAL August 1959.

[2] Maintained at Madison, Wis. in cooperation with the University of Wisconsin.

[3] Italic numbers in parentheses refer to Literature Cited at the end of this paper.

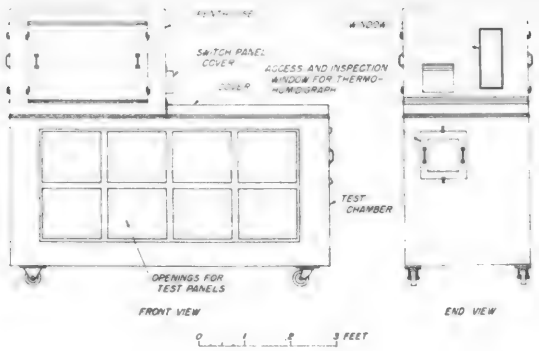

Fig. 1.—Plan of Forest Products Laboratory blister box for paint tests.

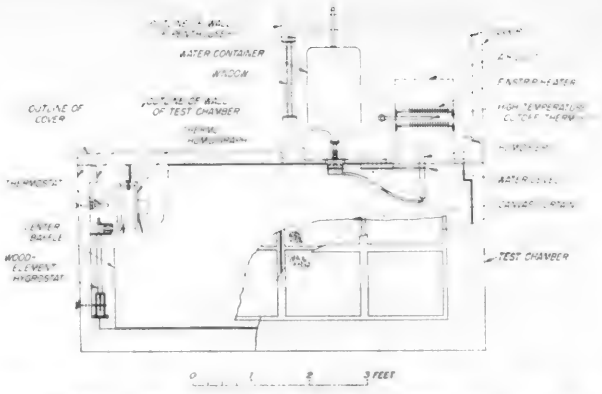

Fig. 2.—Back view cutaway to show air-conditioning and contr components of FPL blister box.

tive of practical conditions on houses. When the blister box was moved outdoors in winter weather, so that the inside could be kept at no more than 80° F. while the outside was at least 30° F. colder, the concern proved well founded. Some paints that blister readily in a temperature gradient from 80° to 30° F. may be resistant in a gradient from 130° to 80° F. Accordingly, the normal procedure at the Forest Products Laboratory since 1930 has been to operate with the outside temperature well below ordinary room temperature. After 1932 the blister box was placed in a room kept below 40° F., so that tests could be made throughout the year and under controlled conditions.

Numerous designs have since been described for laboratory blister boxes in which the interior is kept highly humidified and warmer than the exterior environment (*3,4,7,9,11,13,17*). In nearly all of them the easy way was taken—that of using the temperature of the laboratory for the "cold" side and a higher temperature, up to 140° F., for the inside. The arrangement has been simplified to a beaker of water, kept hot, with a disk of painted wood taped over the top (1).

Iliff and Davis (6), and later Vannoy (14), built small houses on the roofs of their laboratories on which fairly large test panels could be mounted over stud spaces that could be sheathed, insulated, or lined in various ways to simulate ordinary wall construction in frame houses. The interior was highly humidified and kept at normal house temperature while the outside air was as the weather provided. Blistering could be produced consistently only in the winter season.

Teesdale (12) built a full-scale house primarily to study cold-weather condensation with various wall constructions but secondarily to study paint blistering. The interior was kept at conditions of temperature and relative humidity normal for frame residences. An entire heating season was required to complete a set of tests but the tests faithfully reproduced practical conditions of service. Rowley and Lajoie (10) built miniature houses within a large refrigerated room, permitting year-round control of inside and outside conditions.

Werthan (16) described a test panel for paint blistering that was mounted on an ordinary test fence outdoors. The panel consisted of a wood frame about 18 inches square to be set vertically, covered on front and back by painted wood siding with the 2- or 3-inch space between the backs of the boards of siding filled with wet sawdust, which was remoistened daily. If blistering occurred it was said to do so within 4 to 8 weeks.

Hopkins and Smart (5) described an apparatus for circulating air at controlled temperature and relative humidity behind small (2.5- by 4.5-inch) wood panels the painted faces of which could be cooled by proximity to a hollow metal plate through which a stream of cold water flowed. Another apparatus of similar principle was developed by Kuzmak and Sereda (8) who also described devices for measuring the pressure required to blister paint when nitrogen was forced through the dry wood from the under or unpainted side and when water was similarly forced through the wood. Water blistered paints at pressures only a fraction of those required by nitrogen in dry wood.

Veer (15) constructed a two-compartment blister cabinet in which the temperature and relative humidity in each compartment separately could be controlled closely over a wide range. Small wood panels, painted on one side, could be mounted tightly in windows in the partition separating the two compartments. With the device it was shown that sensitive paints, which blister without temperature gradient when free water reaches the wood-paint interface, do not blister under a difference in vapor pressure of moisture vapor however great unless there is also a gradient of temperature sufi cient to cause the vapor to condense t liquid water at the wood-paint inte face. The primary function of a di ference in temperature in paint bli tering is to bring about condensatio of water at the critical junction o paint with wood.

The older blister box of the Fo est Products Laboratory served wel enough to distinguish between highl blister-resistant paints, such as pur white lead paint, and sensitive paint such as the mixed-pigment paints con taining zinc oxide. They also reveale clearly the improvement accomplish ed by use of zincless house paint pri mer in place of self-priming for sen sitive paints. But practical experienc seemed to indicate significant differ ences among sensitive paints that wer not clearly disclosed by the older form of blister boxes. It was felt that th severe conditions previously chosen t produce rapid blistering tended to ob scure the finer differences in blister resistance among sensitive paints. Ac cordingly, the device described here was designed to permit more precis control of the temperature, relative humidity, and circulation of air behind painted test panels, milder conditions of operation, and greater variety of wall construction behind the test panels. Provision was made also for supplying all of the moisture required for blistering in the form of simulated rainfall on the exterior painted faces of the test panels.

Description of the New Blister Box

The new apparatus consists of a test chamber 33 inches wide, 42 inches high, and 84 inches long, on top of which is a penthouse of like width, 31 inches high and 41 inches long. Front and end views of the blister box are shown in figures 1 and 2. The framework of the box is white pine, which was cut to dimensions and then dipped for 3 minutes in a water-repellent preservative. The exterior covering of the box is exterior Douglas-fir plywood.

Table 1.--Rate of gain in moisture content of painted panels during a blister test under conditions of cold-weather condensation

Number of days after starting test	Moisture content of wood attained	Number of days after starting test	Moisture content of wood attained
	Percent		Percent
0	11	8	45.7
1	19.6	9	48.4
2	25.6	10	51.3
3	29.3	11	53.7
4	33.0	12	56.0
5	36.5	13	58.2
6	39.6	14	61.0
7	42.8	15	63.0
		16	65.5

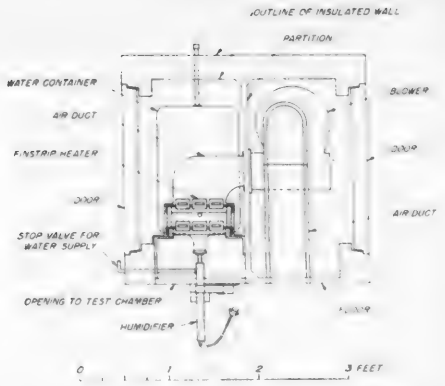

Fig. 3.—Side view of penthouse of blister box with wall removed to show air-conditioning components. Blower has capacity of 400 cubic feet of air per minute.

ıe bottom being 5/8 inch thick and ıe other sides 3/8 inch thick.

The walls of the box, like those of frame house, are framed with 2- by -inch lumber. There are 8 openings ın each of the 2 long sides of the box ı accommodate 16 test panels 15 by 17 inches in size or 4 larger panels 32 by 35 inches in size.

All closed wall space is insulated with 2-inch glass fiber bats, and a good vapor barrier is installed on the inner face of the studs beneath the 1/4-inch plywood sheathing. The bottom of the box is sloped to the center point, where there is a drain, and is lined with copper. The exterior of the box is painted with 2 coats of aluminum paint.

The location of equipment and control apparatus is shown in figures 3 and 4. The penthouse contains a 5-gallon reservoir, a humidifier, 6 500 -watt fin strip heaters, and an air blower with a capacity of 400 cubic feet a minute, operated by a 1/16-horsepower motor.

Control and recording instruments included a thermostat, a thermo-humidigraph, and a wood-element hygrostat. In addition, a high-temperature cutoff thermostat is used in conjunction with the fin strip heaters. A center baffle of plywood divides the test chamber of the box into two parts lengthwise so that the air circulates from the blower in the penthouse down to one side of the test chamber, around the chamber circularly, and back to the penthouse blower. Canvas curtains treated with water-repellent preservative are attached over the interior of the panel openings to simulate the lath and plaster or other interior wall covering of a house and to keep the air in the stud spaces behind the test panels relatively stagnant. The canvas curtains, however, permit diffusion of moisture vapor into the stud spaces from the moist air circulating within the box.

The blister box is mounted on casters to facilitate movement. The exterior environment is controlled by placing the box in a room in which the desired conditions are maintained. For studies in which blistering is produced by cold-weather condensation of moisture originating within the box, it is usually placed in a room kept at 38° F. Many tests have been made, however, in a room kept at 15° F. The air circulating within the box normally is controlled at 72° to 75° F., a temperature representative of customary practice in houses during the heating season. When the outer room is at 38° F., sufficient condensation occurs to blister sensitive paints when the air within the box is held at 40 percent relative humidity. Such conditions may readily prevail in real houses. In order to bring about blistering in a short time, it has been found desirable to hold the air within the box at 50 percent relative humidity. Such a humidity is higher than usually exists for long periods in dwellings at an outdoor temperature of 38° F., but it is still far short of the nearly saturated air usually used within the older blister boxes.

Forest Products Laboratory research has shown that much moisture blistering on houses comes from rainwater that works its way behind painted walls through joints in the construction, rather than from cold-weather condensation of moisture originating within the house. Water behind painted outside woodwork, when the temperature gradient tends to move the water to the interface between wood and paint, has the same tendency to cause blistering as water that originates within the house. Moreover, if paints of high permeability to moisture vapor, such as most latex paints, resist blistering by letting moisture escape from the paint-wood interface faster than it gets there through the wood (4, 7, 14, 15, but see also 10, 18), such protective effect of high permeability would cease when the paint coating is kept wet by water flowing over its face.

Accordingly, the new blister box is equipped to simulate either steady or interrupted rainfall on the painted faces of the test panels. The box can be operated with water supplied from outside only, with both cold-weather condensation and outside water, or with cold-weather condensation only.

For studies in which moisture is supplied from outside only, the box is placed as a rule in a room in which the temperature is maintained constantly at 38° F. and the relative humidity is 85 to 92 percent. No humidification is supplied to the air within the box, which is kept at 72° to 75° F. and comes to approximately 20 percent relative humidity. Under these conditions there should be no condensation of water on the backs of the test panels from moisture vapor originating within the box, but to ensure against condensation from that source the openings in the box are sealed with a vapor barrier of heavy aluminum foil before the test panels are attached.

Rainfall on the painted faces of the test panels is simulated as shown in figure 5. Water is supplied through 1-inch stainless steel pipes suspended at the tops of the 2 long sides of the blistering box. It flows through 1/16-inch openings in the pipes, spaced 1/2 inch apart along the entire length of the pipes. The small sprays of water impinge on the top course of siding of the test panels to run down in streams over the panel faces. Water may be supplied continuously throughout a blistering test, or, if desired, the sprays may be operated intermittently by means of a solenoid valve in the supply line and a clock-work timer.

Test Panels

The smaller test panels shown in figure 2, which are 15 by 17 inches, are made either with 5 pieces of 4-inch or 3 pieces of 6-inch bevel siding held together in a wood frame that simulates butt joints between siding and corner boards or window casings on a house. The small panels are convenient for studies of blistering by cold-

weather condensation. The larger test panels shown in figure 5, which are 32 by 35 inches, are made of 7 pieces of 6-inch bevel siding in a similar frame. The larger panels are used as a rule when the water for blistering is supplied by spraying, and are usually made with butt joints between pieces of siding in the second, fourth, and sixth courses. Panels may be made of other patterns of siding, other kinds of lumber, or of plywood or hardboard when the purpose of the tests so requires.

Before the test is started, the panels are equilibrated in a room controlled at 65 percent relative humidity and 80° F. to bring the wood to approximately 11 percent moisture content. The panels are then weighed and their content of dry wood is calculated, after which they are painted. When the panels have been aged or weathered as described later in this paper, they are again equilibrated in the 65 percent relative humidity room immediately before they are tested on the blister box. The gain in moisture content of the panels during the blistering test can then be determined roughly by weighing the panels at intervals during and at the end of the test.

Test panels are painted in accordance with the objectives of the investigation. Comparisons can be made among house paints, housepaint primers, or painting procedures, and also among kinds of wood, patterns of siding, pretreatments for siding, or details of wall construction.

As a rule, either 2 or 3 coats of house paint are applied on the exposed faces of test panels at spreading rates that result in a final coating 0.005 inch thick when dry. At least 7 days are allowed to elapse after application of the last coat of paint before panels are tested for blistering. Since the sensitivity of many paints changes significantly during the first few weeks of weathering, it is considered desirable to expose the test panels outdoors (on racks inclined at 45° facing south) for 30 days before they are tested on the blister box. The recommendation is based on tests at the Forest Products Laboratory, in which paints were weathered for 10, 30, and 90 days before subjecting them to blistering conditions.

Procedures for Blistering Tests

Despite the rapid circulation of air within the blister box, it was found in preliminary tests that there were variations between the panel positions, in the rate at which moisture was taken up by condensation. For that reason the test panels are moved daily from one position to another in systematic rotation. When that was done and the box was operated at internal conditions of 72° to 75° F. and 50 percent relative humidity and 38° F. outside, panels faced with ½- by 6-inch bevel siding of western redcedar, initially at 11 percent moisture content, gained moisture at the rate indicated in table 1.

Very sensitive paints begin to blister when the average moisture content of the panels reached no more than 22 to 25 percent; that is, within 2 days. Presumably the moisture is not uniformly distributed through the test panels while they are subject to a temperature gradient and for the first few days of a test the wood at the back of the panels must be wetter than the wood at the interface with the paint. In agreement with the findings obtained with an earlier blister box (2), these tests showed that blisters in very sensitive paints may sometimes appear before the wood directly in contact with the coating reaches fiber saturation point and the blisters at that time may not yet be filled with water, although they become filled soon afterward if the blistering conditions are maintained.

Other paints blister when the average moisture content of the panels is 25 to 35 percent; that is, within 5 days. It is still possible that the wood directly in contact with the paint has not yet reached fiber saturation point. More resistant paints blister only after the moisture content reaches 35 to 50 percent or even a little over 50 percent. But paints that do not blister until 40 percent moisture content has been surpassed, blister only slightly or even negligibly. Highly resistant paints that do not blister before the moisture content of the panels reaches 60 percent will not blister on still longer exposure. If blistering is to occur, it probably does so either somewhat before or very soon after the wood immediately under the paint reaches fiber saturation point. The longer it is delayed, the less serious is the blistering.

The usual practice at the Forest Products Laboratory is to keep the test panels on the blister box for 16 days. The panels are weighed at the beginning and end of a blistering test, so that the final moisture content can be estimated. After 16 days under conditions of cold weather condensation, test panels usually come to a moisture content of between 50 and 90 percent.

When the blister box is operated with water sprayed on the painted faces of the test panels only, it has been the practice to spray water continuously for 21 hours each day, followed by 3 hours of exposure without water. After 7 days of such operation, the test panels reach a moisture content between 40 and 50 percent. Under such conditions blistering develops somewhat less rapidly and less extensively than under the conditions of cold-weather condensation. But paints that blister will usually do so within 7 days. Under cold-weather condensation conditions the whole area of the backs of the panels very quickly becomes wet with condensed water, whereas operation with outside water may leave some parts of the panel backs unwetted for a considerable length of time, depending on the manner in which water that penetrates through the joints spreads over the backs of the panels.

Evaluation of Blistering

During exposure on the blister box inspections are made daily and record is made of the time when blisters are first seen, of the relative extent of blistering at the end of the test, and of the final moisture content of the test panels. Until the mechanism of blistering is more fully understood, it is not believed that a count of the number and size of blisters is significant. Each panel, however, is photographed at the end of a blistering test.

Blisters, however, are not of themselves so serious a defect in a paint coating as is the abnormally early peeling or scaling of the coating that may develop later with some paints but not with others. Accordingly, test panels after conclusion of the blistering test are placed on outdoor test racks, sloping back at 45° and facing south, until failure in coating integrity occurs. It is then observed whether, after the wood has returned to the air-dry condition, the blisters recede fully, so that they are no longer observable, or whether the area of the coating has been permanently enlarged by blistering, so that the blisters remain visible as hummocks or ridges. As time passes it is observed further whether the blisters crack and then scale materially sooner than similar unblistered paint begins to fail in integrity. It is also necessary to observe test panels on which the paint did not blister, because some paints that seem to remain free from blisters on the blister box may nevertheless have been impaired sufficiently to crack and flake or scale at an earlier age than they would have if they had not been exposed to blistering conditions. Final evaluation of the resistance of paint to blistering conditions can be made adequately only after the blistered panels have been exposed to the weather.

Conclusion

The new blister box makes it possible to study the resistence of paints to moisture blistering under conditions that resemble closely the actual conditions that may occur on houses. These

conditions are much milder than those previously used in most laboratory blister boxes. In particular, the new device permits study of blistering with water supplied entirely by simulated rain on the painted faces of the test panels. Therefore it is useful in evaluating treatments of siding, such as water-repellent preservatives, that may be effective against outside water but not against cold-weather condensation of vapor from within the structure. The milder conditions of cold-weather condensation used in the blister box are helpful for the closer comparison of paints that blister but vary in their sensitivity. Nevertheless, the most striking differences are those between paints that are highly resistant and paints that are sensitive to moisture blistering.

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A DIVISION REPORT ON . . .

The Wood Composition Board Industry

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A compilation of brief reports from 30 key personnel working in research, production, or sales of wood composition board. The status of hardboards, particle boards, soft boards, and boards of intermediate density is reviewed and summarized.

THIS YEAR'S REPORT ON THE STATUS of the Composition Board Industry is in the form of a news letter rather than formal reports. It was believed that people in the industry could tell a very interesting story if key personnel would each contribute a small amount. Letters were sent to people connected with research, production, or sales of hardboard, particle board, and soft board and to machinery manufacturers in the United States, Canada, England, South Africa, New Zealand, and Australia.

Hardboard

Clark Heritage has preached the doctrine for years that the hardboard people should tailor some of their products specifically for use in dwelling construction. He comments that one of the outstanding accomplishments in the N.A.H.B. research house is the use of hardboard as a structural element in the sidewalls, replacing both sheathing and siding. He also reports that prefinishing and predecorating is spreading among manufacturers and fabricators.

Eugene Tower, Forest Fiber Products' Co., reports that his company has introduced two new products this year and has developed a substantial new use for an existing product. The new products are: 3/8 inch tempered hardboard for panels of exterior siding. This item has several surface patterns and is equipped to give shiplap vertical joints for a tight wall. Their 1/4 inch tempered Rustic board has a shallow striated pattern for exterior board. Sandalwood tempered board, an existing product, is finding extensive use in interior office partitions, laminated to paper honeycomb and other suitable cores.

Masonite's O. G. Sherman, sent information on their Laurel Plant expansion, referred to as unit no 7. This new unit adds 250 million square feet of hardboard production to their existing capacity at Laurel of about one billion feet per year. The plant includes four large presses in sizes up to 5 feet by 18 feet. It also features a new air conditioned, dust controlled building which provides additional space for coating and graining hardboard. Modernization of the existing manufacturing units and the building of unit no. 7 took 3 years and cost over $22 million. All board produced on the new unit is the screen-backed type.

Columbia Hardboard's, Wyman Williams, tells us his company has produced two new items this year. One is a combination product called Triplex, made up of a flakeboard core overlayed with surfaces of medium-density hardboard. The board is made on a three-layer felter, using Bauer ground fibers on each side of a flake core, and pressed in a single operation. The other product is known as "Fire Retardant Cedarwood". This panel has fire-resisting salts incorporated throughout the structure at time of manufacture. The attractive board meets the tests for fireproofed wood in the building laws of N. Y. C.

Kroehler's Torbin F. Yates, reports they are making 1/8 inch and 3/16 inch hardboard in the 65 to 70 pound range in their new plant, using the Emerite binder system. They are producing 40 tons per day in a wide

The Author: J. R. Roberts holds a degree in electrical engineering from the University of Nebraska. A former manager of the Development Center of Weyerhaeuser Timber Co., and research manager of Celotex Corp., he now serves as general consultant.

variety of boards. They expect to be up to 65 tons per day in the near future, and they have a design capacity of 95 tons per day. Their 1 inch board would probably fall into the particle board classification, with a density of 46 pounds per cubic foot. Their raw material is the "leftover wood" from a large furniture frame stock and parts operation. The boards are used as furniture core stock in hardwood veneered panels, the thin panels being used as drawer bottoms, dust panels, case backs and mirror backs. Tempering oils are added to the fiber prior to pressing, then the board is baked to finish the tempering process. The boards are dimensionally stable and are being shipped in large panels on open flatcars. The extra fine fibers are reported to give a very smooth board surface.

R. C. Williams, Emerite Corp., sent data on the Emerite Process, which adds chemicals to the furnish that react with the wood, using chemical parts of the wood as the binding agent. Since this process was mentioned in the preceding item, we would suggest that those interested contact Mr. Williams directly for details. He can furnish a copy of a paper presented in October of 1959 to the Mid-South Section meeting of F.P.R.S.

R. L. Sullivan, Washington Iron Works, reported that his company is building the press and board former for a new Bowater Board plant, and that the dryforming line runs 135 feet per minute. On a 20 shift per week basis that could be a capacity of over 225 million square foot of 1/8 inch board per year.

Robert Stillinger reports that Cascade Plywood Corp. is expanding their hardboard plant from 60 million to 105 million feet annual capacity on a 1/8 inch basis. The expansion should be completed by July 15, 1960. Mr. Stillinger bears out what others have said about the emphasis being placed on filling, sealing, and prefinishing panels. Cascade has completed a modern coating line for plywood and hardboard, which includes a Steinemann coater and a modern ceramic type of infrared dryer. He mentions that they are working on fire proofing and dimensionally stabilization of composition board. He also reports that some furniture companies are interested in 1/16 inch hardboard for crossbonding, and that there is an increase in the amount of special cutting and shaping of furniture parts by cut-to-size suppliers. Cascade has been using the inflated rubber bag system for blocking and dunnage in rail shipments of hardboard and plywood and likes the results.

Malcomb King reports from Australia that Colonial Sugar Refining Co., Ltd. is building a new hardboard plant at Bacchus Marsh, Victoria. Its initial capacity will be 120 tons per day (about 260 thousand square feet of 1/8 inch board per day). This plant will use Australian eucalyptus hardwood, and it will bring the company's total hardboard capacity to over 500 tons per day. Machinery will be of Australian and Swedish make. Colonial acquired the Masonite Corporation (Australia) during 1959.

Mr. King reports that his company, along with Fletcher Mfg. and Timber Industries Ltd., will build Australia's first flake type particle board plant. They will use the Behr process, with an initial capacity of 6 million square feet per year of 3/4 inch board. Construction started in June, 1959, and plant startup is expected for April of 1960. Raw material will be thinnings from *pinus radiata* plantations.

The hardboard industry had quite a good year in 1959. Most of the plants had a good backlog of orders, at least until December 1st. Hardboard is being accepted in new markets at a rapid rate due to the excellent product improvement and development work being done by the manufacturers and fabricators. Very large tonnage is going into house sheathing and prefinished interior panels for both homes and offices. However, new companies are coming into the hardboard field and present manufacturers are materially increasing their production capacity, so the sale of full output will continue to be a tough job.

Particle Board

Peak Timbers Ltd. of Swaziland, South Africa, are marketing a wide range of cut-to-size panels of particle board faced with African hardwood veneer, according to John Sykes. The panels are all 3/4 inch thick, and all four edges of each panel have a veneered surface the same as the flat sides. The surfaces are sanded, ready for a finishing coat. They are particularly attractive to the "do it yourself" trade. In England the panels are sold by Vipboard (Great Britain) Limited. Mr. Sykes also reports that the B.S.I. have almost completed preparation of a set of tests for particle board. These tests are intended to assist the furniture and building industries in selecting boards most suitable for specific purposes.

R. H. Hopgood reports that New Zealand Plywood (South Island) Limited operates the only wood particle board plant in New Zealand. The product is of the flakeboard type, and plant capacity is 5 million square feet of 1/2 inch board per year. Most of the equipment is relatively standard and is of West German origin. They use urea resin as a binder and include an insecticide to protect the board from wood boring insects.

Dr. L. Mitlin of London sends some interesting news concerning increased particle board capacity in the United Kingdom. A new plant at the Airscrew and Jicwood works at Weybridge, began production early in 1959. The Tyne Board Company has just started a plant in the Newcastle area, with an annual output of 20,000 tons. A Baehre type of plant has been installed in Northern Ireland and is now in operation. A chipboard plant is being built in Scotland by William Nairn, and it should be in operation by mid 1960. A plant is being planned for Eire, with its output being pointed at the U.K. market. Scandinavian chipboard is a threat to board made in Britain, particularly in view of the abolition of import duties recently negotiated by the "Outer Seven". There has been a tendency in that area in the last year to reduce chipboard densities and properties, as these have sometimes been better than required.

Max Yan and Dr. Dorland, Abitibi Power and Paper Company Limited, report that new particle board mills are being built in British Columbia and Saskatchewan, while a third one is being rebuilt in Newfoundland. The Canadian Government has issued a specification entitled "Board, Particle Building Construction." Particle board is being widely accepted in Canada as a core for three- and five-ply furniture veneer panels. Initial problems with veneer checking were overcome by keeping the moisture content of the veneer low at time of lamination. New flakers are being offered for sale by the Carthage Machine Co. and the Canadian Sumner Iron Works. The latter, a disc flaker, is the result of joint development work between Sumner and Industrial Development Co. A Boston company, S.A. Woods Machine Co., is offering a "flaker-surfacer" that converts the excess material from rough lumber into flakes instead of planer shavings. The Pullmann Co. is offering a knife hammer mill, reported to produce flakes from small blocks or pulp chips. Several companies are developing a moldable wood fiber-board called "forming board" for the automotive industry.

John M. Crafton writes that he has returned from 2 years in Cuba where he helped build the first plant to make composition board from bagasse by a dry process. He reports the board range from 20 to 60 pounds per cubic foot and have properties similar to those made from flakeboard. The 20 pound board in 1/2 inch thickness

s made into accoustical tile. It also is minated in thicknesses up to 2 inches d used as door cores and partitions. He predicts that there will be a sim- ar plant built in the United States in 960, which will produce dry process gasse boards for various uses. He tes that these are the first particle pe boards made from anything but od in the Western Hemisphere.

W. J. Eason reports that Nickey Brothers finds interest increasing in akeboard with hardwood veneer over- . He knows of several European lants that are curing particle board use of high frequency. The plants e using the very fast press cycle to t substantial production out of sin- le-opening down-stroke presses. He els that improved manufacturing ractices are resulting in improved boards, particularly at the board edges, which make them more adaptable to furniture uses where "raw" edges can be left exposed. Mr. Eason mentioned the new plant which Crossett Lumber Co. expects to have on stream in 1960, and Weyehaeuser's purchase of United Wood at West Memphis, Arkansas.

H. E. Capron, Roddis Plywood, sent some interesting data on his company's expansion of particle board manufacture. Their Arcata, California, plant will increase production by 50 percent within the next 18 months. The new capacity will be 400 tons per day. He reports the present plant oversold on a three-shift 7 day basis. During the past year, they started production of Phenolic Timblend, which they say can be used anywhere that exterior grade plywood is satisfactory. They have a fire rating by Underwriters Laboratories on Phenolic Fire-Treated Timblend.

D. L. Haynes, Tenex Incorporated, says they are specializing in a ¼ inch thick three-layer product and most of it is going as utility board.

Alvin Klotz, U. S. Plywood, writes that their new Novaply Plant will contain 80 thousand square foot of work space. It will be built entirely of wood, and it will be completed in late 1960.

James d'A. Clark reports that a wafer board plant, based on three of his basic particle board patents, will be built by Wizewood Limited of Saskatchewan. The plant will produce medium- and low-density boards of the multi—ply type, up to thicknesses of 1 inch. The binder will be phenolic resin at a usage of less than 2 percent. The plant capacity will be 100 tons per day, and the product is designed to compete with plywood in all important properties.

R. F. Buck, United States Korboard Corp., notes that his company would be interested in exchanging ideas with other particle board manufacturers on common problems relating to the use of particle board as underlayment for vinyl floors.

Wynnewood Product's, Kjell Stordalen says his company has perfected a high-density board using a phenol-formaldehyde binder. They call it Wynnewood 60 F, and it has a density of 62 pounds per cubic foot. Their urea-formaldehyde board has a 63 pounds density. One of their large uses for these products has been school furniture.

National Starch and Chemical's, A. G. Battaglia, reports that his company has acquired the flakeboard plant of the American Parboard Co., Black Mountain, N.C. This product will complement their Granite Board product. During the past year, they introduced a homogenous fine particle board called Granite Board Extra Fine. This product has a hard, smooth, paintable surface, an M.O.R. of 2200 psi, a 24-hour water absorption of 8 percent, a thickness swell of 2 percent after a 24-hour soak, and an internal bond strength of 120 psi according to Mr. Battaglia. They will shortly announce the availability of an exterior type particle board in ⅜ inch and ½ inch thicknesses tailored for use as soffits and gable ends.

Paul J. Bois, Georgia Forestry Commission, submitted limited information on a German process which is being offered in the United States by Soderhamm Machine Co. It is called the Bison–Bahre process. The board is formed in such a way that it has a fine particle surface on both sides with the particles getting gradually coarser toward the middle.

Dale L. Schubert, Industrial Development Company, reports that his company completed development during the year of a new mixer for blending resin and particles. It is a continuously operating high-volume blender with completely automatic control of a preset ratio of resin to particles. The atomizing nozzles are installed externally to allow visual inspection and adjustment and cleaning without interfering with production flow.

Ralph Peinecke, Pope and Talbot Co., reports that his company introduced a new product in mid year called Blendboard. In October, they introduced pre-filled Blendboard and Particleboard. He reports that at the customers request, these boards are factory prefilled with a vinyl compound that permits the use of semi- and high-gloss enamels. The new production line consists of a Laurence automatic feeder, Timesaver Sander, Schmotz coater, special drying tunnel, an automatic panel turner, and a stacker. They have also installed an automatic proportioning system for wood, resin, and wax.

H. C. L. Miller, Miller Hoft says in his opinion, 1959 has been a year of evolution rather than revolution. He cites improvements in process machinery and manufacturing techniques along with better quality control, which have resulted in substantial overall product improvement during the year, while increased automation has reduced labor costs. He mentions specifically: improved flakes, improved mixing techniques, recording methods of resin-flake proportioning, presses with higher volumetric capacity for faster mat compression, automatic mat weighing and rejection stations in the line, and the increased use of fillers to produce super smooth boards.

R. A. Sullivan, Washington Iron Work, reported on an interesting plywood plant. It has 30 openings, closes at 600 inches per minute, and presses at 50 inches per minute, which is a good example of a high-volume hydraulic system. He also mentioned a combination hardboard and particle board press with simultaneous platen closing equipment for Tablopan de Venezuela.

Howard Rogers, Williams–White and Co., described a large special press built for a particle board plant in Canada. The press included a simultaneous platen-closing mechanism which along with a micro-closing control mechanism, should eliminate one of the biggest headaches in particle board plants, namely, the use of stops in the press.

Wayne Lewis, U.S. Forest Products Laboratory, has an up-to-date list of particle board plants available to anyone who wishes to write him for it at the Laboratory in Madison, Wis. Mr. Lewis mentions the trend in the industry toward greater production of particle board with phenolic binders for limited exterior exposures.

The U. S. Dept. of Commerce is circulating a proposed set of particle board specifications for the particle board manufacturers. This is identified as: "Proposed Commercial Standard for Mat-Formed Wood Particle Board TS–5463" inches. Copies can be procured from Commodity Standards Division, Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

Soft and Intermediate Density Board

The manufacturers of softboard are putting more effort into research than they have done for many years. They have two major objectives in this. One is to improve their regular products to

hold and expand their established markets. The other is to develop new products in the intermediate density range which will help them take over markets now supplied by wood and plywood.

The domestic market for acoustical tile is barely being touched. Many millions of fine homes have no acoustical treatment at all. Just as non-insulated homes were taken care of by aggressive merchandisers, years after they were built, so will these "non-acousticated" homes be given at least partial treatment for special rooms in the years to come. Whether this will be done by cellulose tile or mineral tile will depend on the success of the cellulose tile manufacturers in making their products attractive to the housewife and in giving them substantial fire-resistant properties. A great deal of progress has been made on making them more attractive.

The commercial market for acoustical products such as schools, offices stores and others is becoming increasingly difficult to service with cellulose types of tile and board. A good job has been done by the industry in producing coatings with excellent flame-spread resistance. Some are offering tiles that are coated on both sides. However a need exists for fire resistance incorporated throughout the whole board thickness, and a great deal of effort is going into the task. The producers of various types of mineral fiber tile and acoustical board are improving their products and working to reduce costs so as to get an increasingly larger share of this market. The industrial market for acoustical products, principally factories, has a very large potential but requires study as to treating techniques as well as an aggressive selling job. It also will require products of high fire resistance.

Several attempts have been made to make cellulose products fire resistant by adding mineral fiber. However, to be really effective, the mount of mineral fiber becomes so large that it becomes substantially a mineral fiber product.

Within the last year, several soft board manufacturers have introduced intermediate density boards to the market. The biggest usage for this product to date has been as nailable sheathing for homes. When this product is used as sheathing, no wood corner bracing is required and, shingles can be nailed directly to the sheathing.

We hope our treatment of all the data which was sent us is satisfactory to the senders. And again, our most sincere thanks to those of you who took the time to answer our letter.

PREVENTING MOISTURE PROBLEMS IN

Wood Siding in the South

A. F. VERRALL

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Tests showed that southern pine sapwood gives good service as siding and trim, if a few precautionary measures are taken. If included in the original design, little additional cost is involved. In existing structures, danger signs show up before decay begins, and a few simple measures will prevent trouble.

DURING RECENT YEARS WOOD siding has been losing favor in the South; more and more buildings are being sided with asbestos cement, aluminum, and other non-wood materials. Some of this trend results from fear of decay, but more probably it is traceable to paint maintenance difficulties. Decay and some paint failures are evidence of moisture problems. The tests reported here were designed to furnish more precise data on how wood siding is affected by rain seepage under different use conditions; with such knowledge walls can be designed for minimum trouble from moisture.

Materials and Methods

All tests were conducted at Saucier, Mississippi, mostly on a frame building (8 by 32 feet) having 34 siding panels approximately 2 feet wide and 4 feet high (Fig. 1A). Half of the building was constructed in 1948 and the rest in 1950. Treatment were duplicated on the south and north walls. There was no roof overhang and the asphalt shingles were bent down over the top siding board to insure maximum water flow over the outer wall. Originally all studs were open to the air inside the building. Later, pressed wallboard was applied to the inner faces of the studs of 8 panels, but no effect of the wallboard was noted, and no analysis was made.

On the back of each siding board, about 1.5 inches from each end, two copper roofing nails were set to a depth of 5/16-inch (Fig. 1B). These were used as electrodes for periodic determination of moisture contents with a resistance meter.

Four lots of kiln-dried southern pine sapwood siding were tested. (1) 1- by 8-inch pattern 105 drop siding, (2) 6-inch bevel siding, (3) 1- by 6-inch pattern 105 drop siding, and (4) another lot of 6-inch bevel siding. Lots 1 and 2 contained very small amounts of stain; lots 3 and 4 were free of visible fungus infections.

Panels to be compared were matched board by board, except when comparisons were between types of siding or north and south exposures. Such factors as open versus tight joints and various end treatments were equalized for north and south exposures, east and west edges of panels, and tops and bottoms of panels.

The following special features were incorporated in panels:

Sheathing Papers: (a) Breathing papers—asphalt-saturated, uncoated felts weighing 4.3 and 6.9 pounds per 108 square feet respectively. (b) Vapor-barrier paper—2 layers of kraft paper with a core of asphalt on cheesecloth. Panels with no sheathing paper were used as checks.

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[1] A contributed paper received July 27, 19

Joints of Siding to Trim: The bevel and most of the drop siding was butted to the trim. Joints were either tight, or with a 1/8-inch space between the siding and trim. On two panels of drop siding, the trim was placed over the ends of the siding; on one side of each panel the siding ends extended to the edge of the panel under the trim. On the other edge, a 1-inch air space was left at the end of the siding under the trim. In supplementary panels, trim was placed over the ends of bevel siding.

End Treatments: (a) A heavy brush coat of unthinned lead paint on the siding ends, (b) a similar coat on the ends and also the back, (c) a 3-minute dip of 4 to 6 inches of the ends in 5 percent pentachlorophenol plus a moisture repellent, (d) a similar end dip in 5 percent pentachlorophenol alone, and (e) no end treatment. All panels with end treatments had siding abutted to the trim.

Wood Sheathing: The drop siding of 4 panels was nailed over 4/4 by 6-inch horizontal pine sheathing. With two of these panels no sheathing paper was used; with the other two, a vapor-barrier paper was inserted between the siding and the sheathing. Two of the four original bevel-siding panels were reconstructed in 1951 for the purpose of inserting wood sheathing under the breathing paper.

Fungus Infections: In the new part of the building half the ends of six panels were artificially infected—four panels with the common decay fungus *Lenzites saepiaria,* and two with the common mold *Trichoderma viride.* The board ends to be inoculated were soaked in tap water two hours for the mold series and overnight for the decay series. The wet ends were placed in contact with infected pine shavings and wrapped in vapor-barrier paper for 3 weeks for the mold and for 10 days for the decay. At installation the molded boards showed no infection other than the mold; the decay-infected boards showed stain and mold with small amounts of incipient decay.

All outside surfaces of the building were given two coats of exterior white paint (Federal Specification TT-P-40, Type 1, Class A). The building was repainted later.

In addition to the experimental building, auxiliary panels of essentially the same construction were used to test end treatments (Fig. 1C), the effect of roof overhang (Fig. 1D), different corner constructions for bevel siding, and the effect of using furring strips (4/4 by 1-1/2 inches) to provide ventilation between the siding and paper (Fig. 1C).

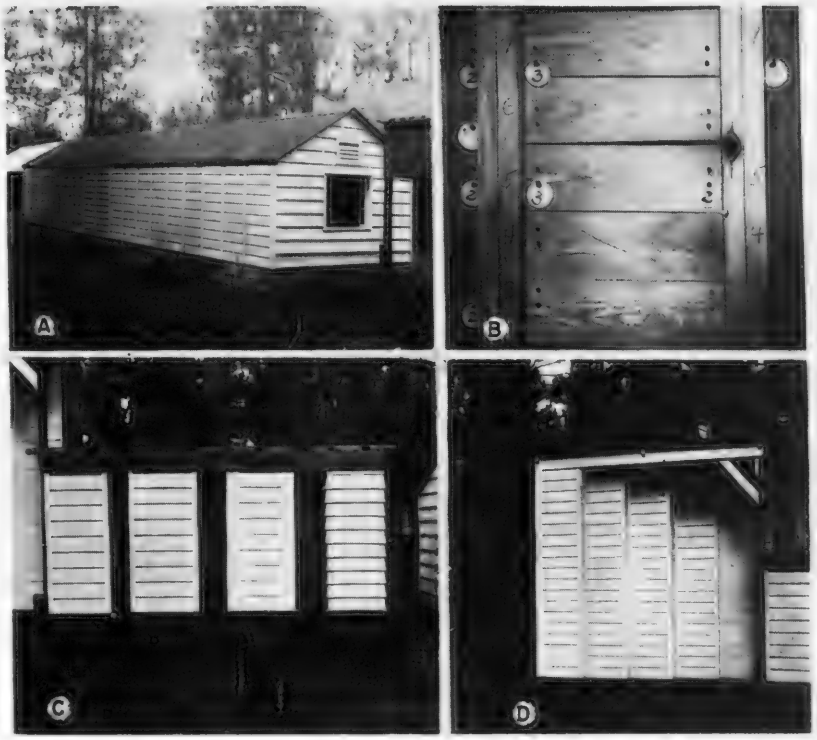

Fig. 1.—Test building and panels. (A) Test building with 34 panels of various designs. (B) Inside view of parts of 3 panels in "A", showing placement of electrodes. (C) Supplementary panel for the study of end treatments. (D) Supplementary panels to study effects of various roof overhangs.

Results

Data on wetting and drying of the test panels have been published (3). Wetting was closely correlated with the decay occurrence reported here. The important points on rainwetting are as follows:

Except in cold-storage buildings, most wetting of siding in the Deep South results from rain seepage. From observations on panels without paper, it appears that drop siding wets mainly from seepage at end points, particularly against trim. Bevel siding wets similarly, but in addition, it wets importantly from water creeping over the lap joint. The lap of drop siding stains, but most decay occurs at end joints. Consequently, it appears that wetting at the lap joint is not important except in terms of paint failure. Wetting of siding by condensate is generally unimportant in the South. However, there is experimental evidence (unpublished) that once water is back of siding it can vaporize, migrate, and condense some distance from the point of entry. This is important only under the most severe exposures. There also is unpublished evidence that unpainted wet siding dries very rapidly, but that

Table 1.--Proportion of board ends sound, with decay, and with sufficient decay to require replacement after 7.8 years' exposure

Type of siding and wall construction	End dip[1]			End paint			No treatment		
	Sound	Decayed	Failed	Sound	Decayed	Failed	Sound	Decayed	Failed
	Percent								
Bevel siding, breathing paper, abutted to trim									
Wood sheathing[2]	83	17	3	50	20	20	36	64	36
No sheathing	92	8	0	70	30	0	55	45	14
Drop siding, no sheathing, abutted to trim									
No paper	100	0	0	75	25	0	43	57	7
Breathing paper	100	0	0	75	25	0	25	75	32
Vapor barrier	67	33	8	33	67	25	0	100	57
Drop siding, no sheathing, breathing paper, trim over siding ends	100	0	0	100	0	0	79	21[3]	21[3]

1/ 3-minute dip in 5 percent pentachlorophenol without a water repellent.

2/ Wood sheathing was added 2.5 and 3 years after construction.

3/ Decay was limited to boards at tops of panels and was associated with roof leaks.

Table 2.--Proportion of board ends sound, with decay, and with sufficient decay to require replacement after 5 years' exposure

Wall construction and siding treatment	Sound	Decayed	Failed
		Percent	
Treated siding (breathing paper, but no sheathing)			
End painted	79	21	0
End and back painted	100	0	0
3-min. dip in 5 percent pentachlorophenol WR	100	0	0
Inoculated with Trichoderma	0	100	75
Inoculated with L. saepiaria	0	100	86
Untreated controls	21	79	46
Untreated siding			
Wood sheathing, no paper	0	100	100
Wood sheathing, vapor barrier paper	0	100	100
No sheathing, vapor barrier paper	0	100	100
No sheathing, breathing paper	21	79	46

in siding covered with usual oil-paint films all important drying is to the inside of the wall. Thus the rate of siding decay and of some paint failures is a function not only of the amount of rain seepage but also of the rate of drying as influenced by wall design inside the siding.

During the first few months after a panel was painted, little seepage occurred, but paint films at joints soon broke and admitted water. Fine breaks at tight joints resulted in as much wetting as joints with openings of ⅛-inch. It is assumed that swelling and shrinkage of the sapwood siding and trim with normal humidity fluctuations crack paint films and that tight joints and painting cannot be relied upon to prevent rain seepage.

When readings for several months were averaged, there was little difference in wetting on the north and south panels. The complete lack of roof overhang permitted roof runoff to flow over the siding regardless of the direction from which the rain came. With any overhang, wetting is importantly affected by the direction from which rains come, because only wind-driven water will reach the siding (*2*).

The occurrence of decay in the siding of the main test building after 7.8 years for the older part of the building is summarized in Table 1 and after 5 years for the newer part of the building in Table 2.

Type of Sheathing Paper: Where no end treatment was used the omission of sheathing paper held failures in drop siding to 7 percent (Table 1); the use of a light breathing paper permitted 32 percent failure; and a vapor barrier paper permitted 57 percent. With end painting or a preservative end dip, there was no difference between panels with no paper and with breathing paper. Some decay occurred in treated ends over vapor-barrier paper. In the second test (Table 2), siding over breathing paper had less than half as much decay as that over the vapor-barrier. Thus, it is evident that for walls subjected to appreciable rainwash any sheathing paper should be of the breathing type, so as to permit rapid drying to the inside.

Type of Joint Between Siding and Trim, and at Corners: With drop siding, the placement of trim over the siding ends helped prevent leakage and decay (Table 1). Abundant observations of siding in use substantiate these findings. Of the various joint designs tested, the only one that importantly reduced leakage at vertical joints in bevel siding was the metal corner. However, these corners were not as effective on bevel siding as the placement of trim over drop siding.

Wood Sheathing: The inclusion of wood sheathing significantly increased the amount of decay (Tables 1 and 2) regardless of type of paper or end treatment used. There is no doubt that if wood, or presumably fiberboard, sheathing is used under wood siding special precautions are needed to prevent rainwetting.

End Treatments: End dips in a water repellent preservative, end painting, and end plus back painting reduced wetting and the amount of decay (Tables 1 and 2). End painting did permit some wetting and decay. End plus back painting was effective, but because paint hinders drying there is a possibility that if leakage occurs the paint will increase the decay hazard. The water repellent preservative also retarded wetting and decay and, being permeable to water vapor, would not hinder drying should water get to the interior of a treated siding board. The preservative without the water repellent prevented decay (except where a vapor barrier or wood sheathing was used), but periodically allowed heavy wetting and therefore did not appreciably curtail paint failures.

Water repellent preservatives (Federal Specification TT–W–572) promise to be among the best means of reducing decay and other moisture-induced problems in exterior woodwork. Their effectiveness is probably due to three factors: (1) The preservative prevents fungus infections and the resultant increased absorbency of wood. (2) The water-repellent reduces capillary creep of water back of siding. (3) When water does reach the treated wood, less is absorbed.

Fungus Infections: As Table 2 indicates, mold infection and incipient decay infections at the time of construction increased decay failures from 46 percent (uninfected at construction) to 75 percent (molded) and 86 percent (infected with incipient decay). This finding substantiates field observations (*2*) that extensive decay soon after construction probably occurs only when poor design features exist in conjunction with siding which had incipient infections at the time of construction. By increasing absorbency of wood (*5*), fungus infections create favorable conditions for decay. In dry wood, decay fungi often remain alive, but inactive, for several years, and they may revive with each rewetting (1).

Unpublished data show that inactive incipient decay infections double the amount of rot occurring in porch columns during 3 years' exposure to rain seepage in the South. If siding is uninfected when applied and the building designed so that excessive rainwash or moisture accumulation is prevented, extensive decay will be rare. For an infection to start, water would have to seep into a joint along with a fungus spore, the spore germinate, and the resulting mycelium develop sufficiently to survive before the wetted wood dried. Such exacting circumstances probably do not occur frequently except with quite faulty design.

Back Ventilation: In one set of supplementary panels, drop siding was held away from the sheathing paper by 4/4 furring strips to provide a continuous ventilating channel back of the siding. After 3 years, no decay was found in the siding over breathing paper whether or not it was back-ventilated. In the siding over vapor-barrier paper, decay had progressed an average of 1.3 inches from the ends in the back-ventilated panel and 4.3 inches in the unventilated panel.

To secure a further indication of the amount of rain wetting, observations were made on the amount of staining and molding on the backs of the siding. The average conditions were:

Vapor Barrier, Unventilated: Except at the ends, where bleaching by decay had occurred in most cases, the siding was molded and stained entirely across the back.

Vapor Barrier, Ventilated: About inches at the ends were bleached white by decay. The decay shaded into a stained area of about the same width leaving a clean oval area at the centers. This indicated considerable wetting but not as complete as in the unventilated panel.

Breathing Paper, Ventilated or Unventilated: One to two inches of mold and stain occurred on the ends, the middle portions being bright. Apparently, wetting was largely limited to the ends when breathing paper was used.

Roof Overhang: The siding of the roof-overhang panels (Fig. 1D) was removed after 7 years' exposure. During half of this time, the back of the siding was exposed permitting such rapid drying after rains that no visible fungus activity occurred. Later a vapor barrier paper was added. Thirty percent of the siding from the panel with 3 inches of overhang showed decay. One of the studs was rotted back of the lower 9 boards, and siding and trim throughout the panel were heavily stained. The panel with a 9-inch overhang showed 1 to 3 inches of stain at the ends of the lower 13 boards, while the top 6 boards showed no evidence of wetting. The siding under a 15-inch overhang showed wetting of the same boards as with the 9-inch overhang, but the stain was very light and almost always limited to the end inch of siding boards. The panel with a 24-inch overhang showed no wetting in the upper 13 boards. The ends of the lower 6 boards showed water stain indicating occasional wetting only.

The data from these tests on the effect of degree of roof over-hang on siding wetting and decay are scanty. However, they corroborate field observation (2) that a 9-inch overhang is beneficial and that 15- to 24-inch overhangs give considerable protection to siding on 1-story buildings. Indirectly, the evidence suggests that eaves gutters would be very beneficial in keeping roof runoff from being blown against walls. Gutters definitely prevent wetting of the base of the wall by splash of roof runoff.

Recommendations for New Construction

It is apparent that siding problems due to moisture seepage are influenced by a number of factors, most of which are easily controllable when a building is being designed.

The following specific recommendations are for wood siding in the Gulf States:

(1) Plan for a good roof overhang, preferably of more than 18 inches for a 1-story house. A hipped roof avoids the more exposed gable ends. On 2-story buildings overhang is less effective unless canopies are added at the top of the first story.

(2) Install eaves gutters to prevent roof runoff from wetting the siding directly or by splashing up from the ground.

(3) Use wood that is free of stain, mold, or decay. Kiln-dried wood is generally safer than air-dried wood.

(6) Use no sheathing paper more impervious to water vapor than a breathing paper. Breathing papers are asphalt- or tar-saturated felts (not coated) weighing not more than 15 pounds per 100 square feet.

(5) Dip siding, preferably for at least 3 minutes, in a water repellent preservative (Federal Specification TT-W-572, or the standard of the National Woodworking Manufacturers' Association) in accordance with the usual treating recommendations (4).

If full-length dipping is precluded, an alternative is to end-dip after cutting to length and to brush-treat the rest. Dip-treated or vacuum-treated siding is on the market, but sawing to length usually exposes untreated wood at the most vulnerable points. Such siding, or even untreated siding, can be given worthwhile protection if the vertical and horizontal joints are sprayed or brushed with a water repellent preservative after the siding is attached, but before it is primed. If the surface is completely covered, priming can be delayed for days without danger of rainwetting.

When wood and probably composition sheathing is used, the protective factors discussed above are particularly important.

A favorite type of construction in the South is the 1-story house with a hipped roof and 24- to 36-inch roof overhang. In this type of building, factors 3 through 5 are probably unimportant. Further north, where condensation in walls is more common, the use of a vapor-barrier directly under siding would seem questionable regardless of roof overhang.

Correcting Trouble in Existing Structures

After a building has been erected the possibilities of eliminating moisture leakage are restricted. Heavy rain seepage into siding and other exterior woodwork is evidenced by early decay and severe paint failures. With moderate leakage decay may not occur for a considerable time, but paint troubles appear early in the vicinity of joints. These include dark discolorations that will not wash off, nail pulling, warping, and paint peeling. All paint peeling, of course, is not due to water seepage, but if it first appears at joints, rain seepage is probably the cause. The following corrections can be made:

(1) Brush or spray a water repellent preservative into the joints before each repainting. Wipe excess oil from the painted surfaces.

(2) If feasible, add sufficient roof overhang.

(3) Add eaves gutters if not present. In many cases this, plus the use of the water repellant (1 above), will correct seepage problems.

When little or no roof overhang is present, the wall construction includes sheathing or a vapor-barrier paper under the siding, and a considerable number of decay spots have developed, the cheapest and most satisfactory treatment often is to cover or replace the wood with properly applied asbestos-cement shingles.

The tests described in this paper were made under southern conditions, where rain seepage often is severe. Nevertheless, the principles developed are applicable to rainwetting problems in other sections. It must be remembered, however, that any moisture trouble arising from condensation, either winter condensation or that associated with air conditioning, must be alleviated by entirely different means.

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Fig. 3.—Conventional low-density ceiling tiles. Left, coated with a decorative paint formulation; right, a latex intumescent coating.

Fig. 4.—Unprotected panel bursts into flame; intumescent coating has bubbled up but there is no burning.

Latex-Fire-Retardant Int

R. B. DRUBEL and W. E. F. RUPRECHT

Coatings

FIRE PREVENTION AND FIRE protection are important areas of concern. Each year in the United States, as a result of fire alone, 12,000 lives are lost and many thousands of injuries are suffered. In addition, material losses amount to one billion dollars a year.

Much of the loss—both human and material—is caused by rapid spread of flame through a structure. Architects and contractors alike are therefore designing and building units with floor-plans and materials that reduce the hazard of rapid flame spread. Building material suppliers are hard at work to produce flame-resistant or flame-retardant products. But many things yet remain to be done.

An area in which significant progress can be made is that of fire-retardant intumescent coatings over low-density wallboards and ceiling tiles. These boards and tiles are extremely important building products. They are low cost, lend themselves to efficient construction techniques, and, in the light of our almost frenzied construction demands, are irreplaceable raw materials.

Intumescent coatings puff up under heat or flame to create an insulating layer over the substrate. Their retardant properties add precious minutes to the safety factors of combustible fibrous boards.

Unfortunately, these fibrous, low-density products also are inherently combustible. They burn easily and quickly—and dangerously. In many instances of severe fire damage where these products have been used, only a few additional minutes would have meant a margin of safety for people to evacuate or for a fire department to act. These important minutes can be bought cheaply and effectively by a factory-applied intumescent coating.

The Author: Richard B. Drubel holds a BS degree from Wagner College and an MS in from North Dakota Agriculture College. He has been with Dow Chemical since 1951; Walter L. F. Rupprecht holds a BS degree from University of Michigan. He has been with Dow since 1952

[1] Presented at Session LX, Wood Finishing, FPRS 13th National Meeting, June 23–July 3, 1959 in San Francisco.

Intumescent Coatings

Fire-retardant coatings embrace both aqueous and non-aqueous systems, and they may be intumescent or not. Intumescent coatings imply a material that puffs up when subjected to high heat or flame, thus providing an insulating layer between the heat source and the substrate. An intumescent coating does not prevent fire, but it is an effective retarder of flame and fire spread. Non-intumescent fire-retardant coatings are materials that contain non-flammable ingredients, or which may generate flame-extinguishing gases when heat is applied, and which may contain borate-type ingredients that become glass-like and heat reflective.

Intumescent Agents

The three types of intumescent agents used complement one another to develop a serviceable three-part intumescent system. Briefly, the organic nitrogen compounds are "blowing agents" that result in puffing up of the coating film, thus providing an insulated zone above the substrate. The organic fire-retardant salts release gases that smother flame and also function as blowing agents. Non-resinous carbonaceous compounds (and the latex) are affected by the blowing agents.

Fi 5.—Intumescent-coated tile shows no flaming while the decorative-coated tile is nearly burned through.

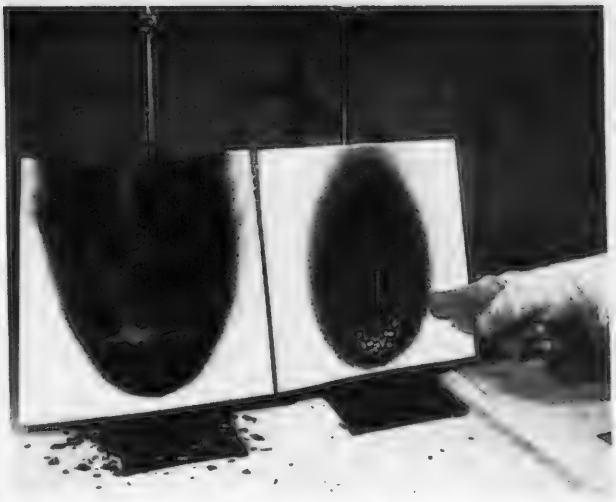

Fig. 6—Intumescent-coated tile shows effect of 25 minutes direct flame. Decorative-coated tile is burned through.

t Intumescent Coatings

Coatings Technical Service, Dow Chemical Company

They are the materials that puff-up or intumesce.

The intumescent formulations discussed here are designed for application onto low-density vegetable or wood fiber boards as an integrated part of the board manufacturing process. The formulations possess important practical characteristics. Some of these are:

1. They have ample wet coating life to allow a wide latitude in handling.
2. They are readily formulated.
3. Dried films are water and scrub resistant.
4. Dried films possess good color retention and do not check on aging.
5. Dried films have superior intumescent fire-retardant properties.

These intumescent formulations are unique in the employment of vinyl chloride copolymer-type latexes to bond the intumescent and other ingredients into the paint film and to give adhesion of the paint film to the substrate. An added advantage of vinyl-chloride latex is its self-extinguishing characteristic.

Formulating Ingredients

Latex-bound intumescent formulations commonly include the types of materials shown in Table 1.

Table 2 gives typical materials for each of the three intumescent classes. By varying these materials in different formulations, the most useful combination of intumescent ingredients was selected. The criterion for selection was satisfactory intumescent quality of the dried coating and a resultant pH of the aqueous mixture of 4.0 or higher. Satisfactory intumescence may be described as the ability to bubble-up with heat to form at least a $\frac{1}{8}$-inch foamed insulating layer, which will withstand flames for extended time periods.

Table 1.—TYPICAL INGREDIENTS IN AN INTUMESCENT FORMULATION

1. Intumescent Agents
   - A. Organic nitrogen compounds.
   - B. Inorganic fire-retardant salts.
   - C. Non-resinous carbonaceous compounds.
2. Pigments
3. Latex Binders
4. Plasticizer
5. Thickener
6. Water

After an extensive evaluation of the ingredients listed in Table 2, the most promising compromise of intumescent and latex coating properties to be attained consisted of a combination of:

Dicyandiamide
Monammonium phosphate
Pentaerythritol

Table 2.—CLASSIFICATION OF MATERIALS FOR INTUMESCENT COMPOSITION

Group A
Organic Nitrogen Compounds
Dicyandiamide
Urea
Guanyl urea phosphate
Glycine
1,3-Dimethylurea

Group B
Inorganic fire-retardant salts
Monoammonium phosphate
Diammonium phosphate
Dibasic calcium phosphate
Ammonium sulfate-phosphoric acid (3 to 2)
Ammonium sulfamate-sulfamic acid (1 to 1)

Group C
Non-resinous Carbonaceous Compounds
Starch
Mannitol
d-Galactose
Glucose
Pentaerythritol

Figure 1 shows the area of a trilinear diagram within which satisfactory intumescence was obtained with these ingredients. This combination also represents relatively low water solubility compared to other ingredients tested, thus enhancing the wet scrub resistance of the coating. The latex binder solids content chosen for the coating compositions of Figure 1 was 15 percent, which is approximately the lowest level consistent with any degree of coating film properties for this system.

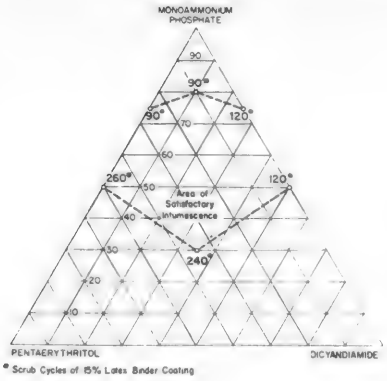

Fig. 1.—Effect of composition variation on coating properties.

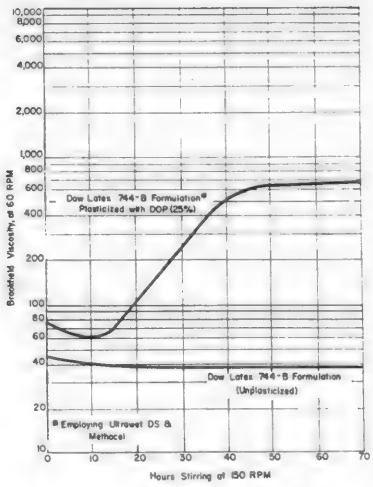

Fig. 2.—Viscosities of latex-bound intumescent coatings.

Pigments

Pigment influence in the generalized formula was not studied in detail. Titanium dioxide was selected solely on the basis of superior hiding power to obtain a decorative as well as protective coating. Considerable information[2] has been reported on the use of pigments and fillers in fire-retardant coatings. It was not intended to overlook the value of certain specific pigments in intumescent coatings. It is assumed that the benefits resulting from a proper choice of these inorganic filler materials would be supplemental to an intumescent system. The only known limitation of additional pigments is that they must be stable at a pH of 4 or greater.

Latex Binder

The utility of latex as a binder is recognized throughout paint and allied industries. A water system has obvious advantages in easy viscosity adjustment, in lack of solvent odor and solvent fire hazard, and in ease of application and clean-up.

The latex used in this study is Dow Latex 744-B, which is a vinyl chloride/vinylidene chloride copolymer. Both plasticized and unplasticized Dow Latex 744-B show very good compatibility with the intumescent ingredients. Acrylic, acrylonitrile, vinyl acetate and styrene/butadiene homopolymers and copolymers were also evaluated, but they were found lacking in the necessary compatibility required for industrial handling.

When dried at room temperature, the vinyl chloride/vinylidene chloride latex deposits a non-flammable, high melting, white powder. To form a film at low drying temperatures, the latex must be modified with film-forming latexes, plasticizer emulsions, or certain liquid plasticizers. However, when drying temperatures at or near the fusion point of the polymer are used, polymer particle coalescence is good. Dillon Matheson, and Bradford[3] pointed out that polymer particle size and relatively low polymer viscosity are significant factors contributing to particle coalescence. It is possible, then, to utilize the latex as a binder material when heating is used to lower the viscosity of the microscopic polymer particle.

Plasticizer

Plasticizers are liquid or solid materials that soften or otherwise affect the properties of resin and latex particles. Commonly, plasticizers impart or improve latex film formation without the use of high temperature.

Latex-bound intumescent formulations containing liquid (chemical) plasticizers develop quality film properties at temperatures as low as 200° F. Blistering of the coating on some manufacturers' primed board during drying at elevated temperatures (250° F or greater) may be prevented by low temperature fusion (200° F) of the plasticized latex coatings. In practical terms, the liquid plasticized latex formulations mean less tendency to blister, faster operation and greater economy than when the non-plasticized latex is used.

Inadequate wet mechanical stability of some formulations containing liquid plasticizer has been noted. However, the use of Ultrawet DS as a plasticizer emulsifying agent and the use of Methocel as the protective colloid results in plasticized formulations which have fully adequate wet mechanical stability. The two liquid plasticizers which have shown best utility in formulations with vinyl chloride/vinylidene chloride latex are dioctyl phthalate and Santicizer 141.

Thickener

Latex systems, being water dispersions of polymer particles, require a thickener to gain desirable coating viscosities. This is in contrast to the use of solvent-soluble resins which are solids or heavy, viscous liquids that must be dissolved in or cut by solvent to attain desired coating viscosities. In the intumescent coatings developed to date, Methocel and sodium alginate have shown high efficiency.

Mechanical Stability and "Pot Life"

Intumescent formulations must have good mechanical stability and must maintain a controlled viscosity range for 72 hours or longer. Otherwise the coatings would not function properly on application equipment in the factory, and made-up formulations would not have sufficient and practical aging properties. The wet mechanical stability of vinyl chloride/vinylidene chloride latex bound intumescent coatings has proved sufficient in plant trial runs on commercial coating equipment. No problems have arisen because of shear, wetting out, or stratification.

The "pot life" or controlled viscosity over a period of time of latex bound intumescent coatings is a measure of the formulations' over-all stability in the plant environment. Figure 2 shows the stable viscosity of the latex systems at 0 to 70 hours stirring at 150 RPM. Such continuous agitation is not necessary or recommended, but it does give evidence of satisfactory performance under conditions far more rigorous than normal.

Scrub Resistance

The wet scrub resistance of an intumescent coating is important to its commercial utility. The ability of a coating to withstand a given number of scrub cycles is closely related to the degree of fusion of the polymer particles. Also implied in the number of scrub cycles are factors concerning adhesion, toughness, washability, and humidity resistance.

Unplasticized latex formulations have attained scrub resistance as high as 1000 cycles; however, this degree of resistance is obtained by subjecting the coating to heat at 300° F or greater and for periods of time running as high as 4 minutes. The plasticized latex formulation gives more than adequate scrub cycles at much lower fusion temperatures and with consequent less danger of blistering the coating during drying.

To acquire the data shown in Table 3, standard formulations were applied to prime-coated insulation board. A

[2] Murray, T. M.; Liberti, Felix; and Allen, A. O. Presented at 123rd Meeting A.C.S., Los Angeles, March 1953.

[3] Dillon, R. E., Matheson, L. A., and Bradford, E. B., J. Colloid Sci., 6,108 (1951).

formulations were spray applied at 30 dry pounds per 1000 square feet. The contrast in scrub resistance, char weight, and char area at different drying times and temperatures is shown.

Table 3.—PHYSICAL PROPERTIES OF LATEX INTUMESCENT FORMULATIONS[1]

Drying Time minutes	@ °F	Char Area Sq. In.	Char Height In.	Scrub Cycles
		Unplasticized		
2	300	7.6	2/16+	400
2	250	---	---	---
2	200	---	---	---
4	300	7.6	3/16	500
4	250	7.3	3/16+	100
4	200	---	------	---
		Plasticized		
2	300	6.7	2/16	400
2	250	6.6	2/16+	300
2	200	6.9	2/16	300
4	300	6.9	2/16+	450
4	250	6.9	2/16+	400
4	200	7.3	2/16	300

[1]Latex formulations were Dow Latex 744-B, unplasticized or plasticized with dioctyl phthalate (5 25).

Test equipment used was the Gardner Straight Line Scrub Tester. The procedure followed was that of Federal Specification 5, Section E9, Paragraph F31. A 1-pound weighted brush was drawn horizontally across the coated board at approximately 40 oscillations per minute. The 0.5 percent soap solution maintained the board in a wet condition during the test.

The unplasticized latex formulation required a temperature of at least 300° F for 2 minutes to develop significant scrub resistance. The plasticized latex formulation develops good scrub resistance at 200° F with 2 minutes oven dwell time.

Scrub resistance data, such as has just been discussed, is affected by two additional considerations: the board surface and the prime coat applied to the board. Different manufacturers produce boards with varying surface characteristics; the prime coats give varying degrees of holdout of the intumescent coating. Therefore the data shown in Table 4 was collected. Table 4 gives scrub resistance data for a plasticized and an unplasticized formulation spray applied at 30 pounds (dry) per 1000 square feet.

Table 4.—LATEX INTUMESCENT FORMULATION APPLIED OVER FOUR DIFFERENT BOARDS

Primed Board*	Char Area Sq. In.	Char Height In.	Scrub Cycles
	Unplasticized		
A	7.8	3/16	500
B	5.8	2/16	300
C	7.8	2/16	300
D	7.5	2/16	1000
	Plasticized		
A	6.9	2/16+	450
B	5.9	1/16+	300
C	5.4	2/16	1000
D	7.2	2/16	900

*All boards were dried 4 minutes (@ 300°F except for manufacturer C's board. C board was first air dried, followed by 4 minutes fusion (@ 300°F because the coating blistered when placed directly into the 300°F oven.

The blistering encountered on manufacturer C's board during drying is believed to be a function of the prime coat. Although a study of prime coats is not within the scope of this discussion, it is apparent that prime coatings which allow some water penetration during application do not trap water during drying and do not cause blistering.

Fire Resistant Properties

The ability of an intumescent coating to withstand fire is quite obviously the major factor in its utility. A standard laboratory method for screening the fire resistance properties of a coating is the Commercial Standard Test CS–42–49. In this test the maximum allowable char area for board samples is 12 square inches. All Dow latex intumescent formulations give char areas well below the maximum.

This is seen in the data in both Tables 3 and 4. Further, these same formulations readily pass the more strict requirements of the Federal Specification SSA–118b (Class C).

Figures 3, 4, 5 and 6 show a laboratory demonstration of the effectiveness of intumescent coatings as compared to decorative coatings when subjected to a flame of intense heat. The flame was removed after 20 minutes, and no continued burning was encountered on the intumescent coated panel. Only a charred spot, ¾ of an inch in diameter, on the back side of the sample, was evident. In comparison, when the flame was removed from the decorative panel after 6 minutes, it continued to burn profusely until it was extinguished by observers after a total time of 12 minutes.

Suggested Formulations

Tables 5 and 6 present suggested formulations for both unplasticized and plasticized intumescent coatings. The tables contain the formulating procedures and sources of the various ingredients.

Table 5.—UNPLASTICIZED LATEX INTUMESCENT COATING

Ingredients	% Solids	Formulation F–519–11–1 Dry	Wet
Water	-		42.3
Monoammonium Phosphate (1)	100	56	56
Dicyandiamide (2)	100	10	10
Pentaerythritol (3)	100	22	22
Titanium Dioxide rutile	100	12	12
Dow Latex 744-B	50	25	50
% Total Solids	65		
%Binder Solids	20		

Formulating Procedure
1. Slurry all the ingredients together except the latex and pass through a high speed stone mill. 2. Add the latex to the pigment slip with moderate agitation.

Manufacturer's Source
(1) Victor Chemical Co., Monsanto Chemical Co.; (2) American Cyanamid Co.; (3) Heyden Chemical Co., Trojan Powder Corp.

Table 6.—PLASTICIZED LATEX INTUMESCENT COATINGS

Ingredients	% Solids	Formulation F–570–2–3 Dry	Wet
Mix A			
Water	--	------	44
Monoammonium Phosphate (1)	100	56	56
Dicyandiamide (2)	100	10	10
Pentaerythritol (3)	100	22	22
Titanium Dioxide (rutile)	100	12	12
Mix B			
Dow Latex 744-B	50	18.75	37.5
Dioctyl Phthalate Emulsion*	50	6.25	12.5
50 cps. Methocel (4)	5	0.125	2.5
%Total Solids	63.4		
%Binder Solids	20.0		

Formulating Procedure
1.) Slurry ingredients of Mix A together and pass through a high speed stone mill. 2.) Combine ingredients of Mix B with moderate agitation and add to Mix A.

*Plasticizer Emulsion	% Solids	Dry	Wet
Dioctyl Phthalate	100	100	100
Ultrawet DS (5)	30	5	16.7
Water	-	---	83.3

Add the wetting agent to the plasticizer and mix vigorously while slowly adding the water. Cowles, Eppenbach or Kady Mill mixers are satisfactory for emulsification.

Manufacturer's Source
(1) Victor Chemical Co., Monsanto Chemical Co.; (2) American Cyanamid Co.; (3) Heyden Chemical Co., Trojan Powder Corp.; (4) Registered trademark of The Dow Chemical Co.; (5) Atlantic Refining Co.

Summary

Factory-applied latex intumescent coatings provide a very effective means of retarding the flame spread rate of combustible wood fiber products. The intumescent, fire-retardant composition was developed from a study of three-component systems. The most useful system contained monoammonium phosphate, dicyandiamide, and pentaerythritol. A synthetic latex binder of the vinyl chloride/vinylidene chloride type was selected for the intumescent coating system from a group of commercial latexes. The combination of these ingredients results in a fire-retardant coating that passes Commercial Standard CS–42–49 and Federal Specification SSA–118b (Class C).

The synthetic latex binder utilized with or without a plasticizer requires a drying schedule sufficient to coalesce the latex polymer particles. Because scrub resistance of the intumescent coating film is dependent upon fusion of the latex binder, the wet coating must be dried properly. In facilities where short drying schedules and/or low temperatures (200° F) drying ovens are available, the plasticized latex coating permits a wide latitude of fusion conditions in which optimum properties may be obtained.

ONE COMPANY'S EXPERIENCE IN PROVING

New Laminated Wood Products

ROBERT J. HOYLE
Assistant Director of Research Potlatch Forests, Inc. Lewiston, Idaho

Fig. 1.—Static bending test on 3-inch Lock Deck.

Many product ideas are conceived, but few become realities. The road from laboratory to marketplace must be paved with sound research, development testing, realistic working stresses, market analyses, and trial installations. We must prove the product to the user . . . but first we must prove it to ourselves.

IMPORTANT NEW PRODUCTS for the wood-using industries will be based on laminating procedures. These new products will have to be developed under adequate test programs and quality control methods, and they will have to be properly presented to the market.

This paper is not so much concerned with manufacturing techniques of laminated products as it is with experience gained in bringing a new product from the laboratory to the marketplace.

The product, a laminated wood roof decking known as "Lock-Deck," was brought from the idea stage to full and expanding production in 18 months. Largely on the basis of its advantages as a well-seasoned product with good coverage characteristics, simplified nailing techniques, low installation cost, and durable glue lines, the new deck achieved early success.

This is not intended to be the "last word" on the introduction and proving of new products. It is the story of one company's experience presented in the main, in a nontechnical fashion. It is presented with the belief that many phases of our experience in introducing this new product will have general application.

The Author: R. J. Hoyle attended Cornell Univ. and the College of Forestry, N.Y. State Univ. He holds a BS in mechanical engineering and an MS in forestry.

Product Development

Many of the activities of our research department can only properly be classified as product development. This requires some fundamental studies of certain aspects of the development that have never been fully investigated before. It is largely a job of designing a technically producible and structurally sound product, evaluating its properties and assessing its merits from the viewpoint of the user, and learning how to produce it profitably at a cost in proper balance with its value. We also firmly believe that the job of presenting the new product to the market is a function of the research department and it should include control of selling price and distribution as long as the product is a research department project.

Product development demands realistic appraisal of the advantages that the improved material offers to the designer and builder. Great changes in the way that building materials will be used and marketed are taking place today. Changes in the values people place on good design and use of materials are evident. People are more aware of the security, comfort, and durable values of artistically designed structures—be they homes, schools, supermarkets, or public buildings. Herein lie opportunities for well conceived quality wood products as well as other building materials. We do not feel that wood products must always meet the lowest cost competition.

We should be guided by the idea that our industry achieve the best return from its material resources, not merely a profitable return, but the most profitable one. We cannot simply develop products that the average mill can produce. Most of us recognize the need to become better or different than the average in the sense that we make building materials unlike traditional types. This means using different skills, different plant facilities, and different production management tools than any we have been using in the past.

The evolution of new and superior adhesives for wood is well known. Adhesive costs, not only of the basic resin but the costs per thousand board feet of product receive a great deal of attention. Adhesives suitable for building products are not particularly cheap and it requires much research effort to develop a manufacturing method that will yield economically attractive statements on production quantities of laminated products.

The wood products industries must know enough about the processes and materials of interest to them to reach their own decisions about the paths to follow in research and development work. The time when this industry could entrust the creation of new

[1] Presented at the 1959 Wood Industries Conferences held by FPRS, AIChE, and ASME, Sept. 10-12, Portland, Oregon.

machines and materials completely to our suppliers is definitely past.

Proving the Product to Ourselves

Many product ideas are conceived, but relatively few ever become realities. Evaluation of product ideas is the first task of the researcher in his kind of work. He must do this to assess its potential, establish the validity of initial claims made for it, and decide upon the market opportunities that may exist. The idea must withstand very critical examination at this point, including some testing work, market survey, and manufacturing studies.

Laboratory studies will reveal design problem solutions and permit estimates of manufacturing costs. To study market acceptance, the well-considered opinions of experienced sales department personnel are valuable. Investigations may also be employed to real advantage. These often take the form of discussions with potential users. Conferences with architects, builders, building material dealers, and building officials are a good means of estimating the marketability of new products. These people display an encouraging interest in new products and are willing to give their varied viewpoints. Constructive suggestions from these conferences pave the way to trial service installations and trial marketing studies.

It is necessary to have as much engineering design information on hand as possible at these conferences. These people want specific information and they are favorably impressed when you can show evidence of real preliminary work. Product appearance, finishing information, installation methods, structural properties, and such physical characteristics as acoustical and thermal insulating properties help develop constructive discussion and suggestions. Costs are of primary concern; and, even though they may be tentative at this stage, they indicate the extent to which the idea has been pursued in the laboratory and field.

These calls should be made by technically trained men who understand sales work. Market research men have often taken an active part in development and testing work on the new product. At this stage the product idea is still being evaluated.

To execute the study of manufacturing methods, a laboratory production of quantities sufficient for trial installation is highly desirable. Production of sizable amounts of the product permit installation studies leading to development of suitable installation methods and realistic estimates of installation costs. These costs are of utmost importance in appraising the potential of a new product.

Fig. 2.—Full scale load test on 4-inch Lock Deck.

Trial installations by selected builders reveal user reaction. The attitudes and observations of several builders making such trial installations form a part of the research records. Technical personnel from the research department participate in the trial installations to observe, to explain recommended procedures, and to instruct in the use of proposed new methods. The term "selected builder" has been used to indicate the need for choosing trial installers with experience in applications of the general type for which the new product is designed. If a new product is used by persons who have never used products serving the same function before, no basis for comparison exists. Such persons are unable to appraise the product intelligently.

The availability of substantial quantities of the new product makes it possible to test material with characteristics much like those of the product that will ultimately be marketed. This increases the confidence placed in the results of the test program.

Developing Structural Properties

The methods used to determine working stresses and elastic properties of new building products are of great concern. It has been customary to assign strength values to wood products by methods that are based on the application of strength ratios to the basic stresses established for clear material. This method is well documented and can be applied effectively to some timber products. Testing of actual samples of laminated products, however, yields results strikingly different from those obtained by the above "synthetic" method.

Modulus of rupture tests on over 100 pieces of laminated western red cedar randomly chosen from production over a period of 6 months yielded working stresses fully 40 percent higher than the "synthetic" methods would allow. These working stresses were obtained by applying the same strength-reducing factors to the test averages than were used in obtaining basic stresses for clear material and include the consideration of material variability, duration of applied load, and margin for accidental overload. Similar results have been obtained on smaller samplings of other species.

Modulus of elasticity results did not show such large variation from the generally accepted values. Even here, some increases in elasticity values for design seems appropriate.

There are several reasons for these differences in the case of laminated products. The sources of timber are more limited than the sources of material sampled in the establishment of properties of clear material. Those samples contained proportions of weaker material from areas not included in our timber resources.

It has also been the custom to assume that seasoning defects will offset strength gains as green timber seasons. Where products made from carefully seasoned material leave the manufacturer's plant free from serious defects, it is reasonable to admit larger strength values than those credited to the unseasoned material. These reasons do not entirely explain the observed difference and we attributed the remaining difference to the fact that the wood strength properties based on the sampling of selected trees is less indicative of the timber going into our pro-

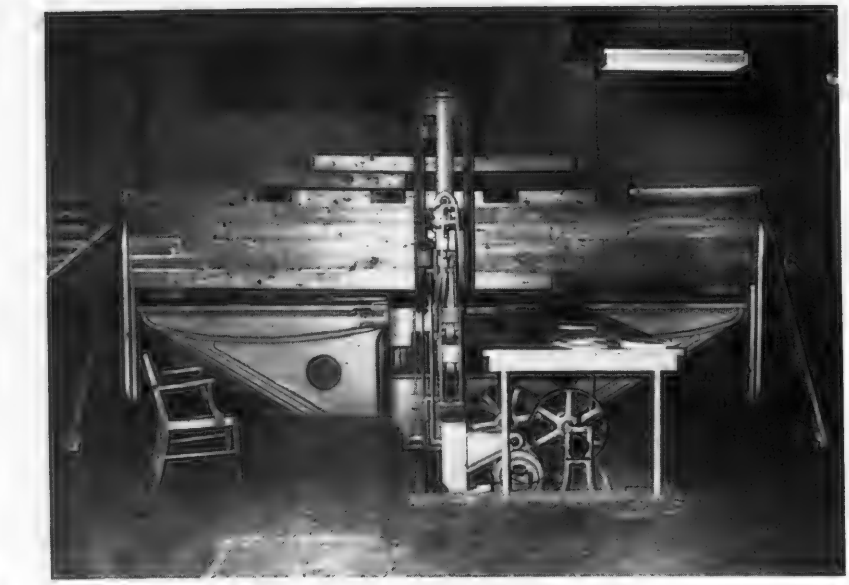

Fig. 3.—Diaphragm test of 3-inch Lock Deck on 16-foot span.

ducts than sampling from the production line.

On the basis of our tests, we believe that parallel-to-grain shear stresses permitted for laminated products are also depressed far below those obtained by testing from the production line.

As the lumber industry develops improved methods of inspection and classification of timber products, high- and low-strength material will be segregated even more efficiently, which will result in better utilization. The testing of products as a basis for determination of strength properties seems to us a more realistic way of arriving at design stress values than the assignment to a species of mean values based upon sampling of the sources of merchantable trees as a broad whole.

The current trend of sustained yield forest management has the effect of reducing variability of the material resource. Returning again and again to the same forest region to harvest timber reduces the opportunity for introducing wood of distinctly different quality into a particular mill's timber supply.

Another reason for testing each new product, as it is developed instead of relying upon synthesized strength values, arises from the influence of processing methods on strength. It is known, for example, that high-temperatures drying influences timber strength. Special processing methods could either reduce or increase strength properties. Reliance upon synthetic test methods for developing working stress data could permit material of substandard quality to enter the market undetected or disallow the advantages of superior materials.

In developing the new deck extensive tests were conducted on timber diaphragms. While these tests did not show results much different from those obtained on conventional timber decking diaphragms, they did indicate methods to follow to produce deck structures with superior diaphragm characteristics.

Proving the Product to the User

The building industry, because it has been using many materials and types of construction that have changed but little over a period of many years, tends to place confidence in those traditional items that have served it well. The building construction industry also has experience with less satisfactory traditional materials, and it is very interested in using some improved building products. By its nature, this industry is not set up to appraise new products. The new building product is greeted with extremes from ready willingness to hesitancy toward acceptance and use. Builders, architects, F.H.A. field offices, and building officials are all concerned. Many among these groups can discern the economic advantages and technical values of the new building product. Some rely upon the appraisal and recommendations of other individuals and committees within their own ranks. It is to these specialists that claims must be formally submitted and proven.

Laboratory tests must be supplemented by the reports of independent testing organizations. It is decidedly worthwhile, in some cases essential, to employ the independent research organization in the evaluation of structural performance and fire-test ratings of new building products. It is often an advantage to obtain the review, approval, or acceptance of new nonstandard building products, if they are to enjoy the widest possible markets. As simple a product as the new deck was not accepted in certain areas where solid wood decking was used. The main difference in these products was the glued laminated feature, yet it was necessary to submit extensive evidence of structural properties as well as glue line durability and manufacturing quality control to gain acceptance in certain important market areas. The cost of these acceptance procedures, while not particularly great in terms of examination fees, was quite large in terms of preparation of the applications and all the supporting information and testing.

The F.H.A. does not approve, endorse, or accept individual materials or products. It does determine how individual materials and products are to be used in properties offered as security for insured mortgages. F.H.A. headquarters in Washington, D.C. determines proper use from a technical standpoint only Final determinations are made by F.H.A. field offices. The field office is able to reach an independent decision on the suitability of a material or product for use in its jurisdiction. The Architectural Standards Division of F.H.A. desires, among other things, a record of experience on new products as an aid to determining proper use. While this might imply prior use in non-F.H.A. insured construction, the field offices are extremely interested in improved materials and helpful in permitting trial use of new products where the merits of the product appear satisfactory for the use intended.

Association activities in grading and glue line certification can be effective methods of protecting the public from sub-standard new building products. Such services are available, and they are being enlarged to aid in the introduction and ready acceptance of new or non-standard building products.

Codes and standards, despite their recognized value, tend to be restrictive upon new products. They often fail to include all usable species of timber. This presents difficulty in the use of some species for new building products where these species have not customarily been used. More active participation by the wood products companies in Commercial and A.S.T.M. Standards work seems desirable. Otherwise standards become adopted that do not adequately consider the future with respect to new and improved materials. Such standards may be restrictive beyond their real intent.

Standards on laminating that specify such things as glue spreads may inhibit the development of improved bonding techniques and processes that can improve the economic feasibility of laminated timber products. In preparing documents to serve broad areas, ca

should be taken that they do not restrict interest in the use of new processes of real merit. As in code work generally, the superiority of performance standards over specification standards seems evident.

To market some products, a certain amount of training of the applicator is necessary. This is less a problem for products sold to the home manufacturer or the large and well-organized contract builder. For the smaller builder, subcontracting major parts of his job and using relatively unskilled labor, this can be a serious obstacle.

The question on defining a satisfactory test often arises when evidence of performance of a product is being prepared. This is especially true where the fundamental performance requirements are not known or well understood. Many building products or constructions are accepted because they have proven themselves in service for decades. Since they were not originally designed by any scientific method, they may have properties beyond the actual requirements for the job. Being satisfactory, they stand as models for new product developments—models that are restrictive and unnecessarily costly to duplicate.

Conclusions

New building products face obstacles to acceptance not faced by such products as household appliances, automotive engine materials, air-conditioning units, or machine tools.

Good technical salesmanship and company reputation will introduce new building products in many areas. Large quantities of several new products have been placed on the market and proven in just this way. This experience gained in the use of new products initially introduced in this way, probably has a favorable influence upon ultimate acceptance by examining agencies. It is often desirable, but not always necessary, to gain early approval by building officials, code groups, and governmental agencies for initial sales.

We should pay attention to the growing pattern of control over the introduction of improved products. Our interest should lie in avoiding growth of a restrictive and unduly costly and time-consuming type of control.

Continued studies to determine the reasons for discrepancies between synthetically derived working stresses and those obtained by proper sampling of production are needed. The old method of establishing properties by sampling of selected trees, which may have had merit when conceived, no longer seems appropriate for laminated products manufactured under conditions subject to control.

CONSTITUTION AND BYLAWS ADOPTED BY

New Society of Wood Science and Technology

BY MAJORITY VOTE THE MEMBERSHIP of American Institute of Wood Engineering has recently adopted a new Constitution and Bylaws and in so doing has changed the name of the organization to *Society of Wood Science and Technology*. Over two thirds of the 175 charter members cast ballots, with but four dissenting votes.

The original constitution, accepted on a tentative two-year basis by the membership at the 1958 Annual Meeting held in Madison, Wisconsin, was reviewed by a committee composed of Eric A. Anderson, James S. Bethel, Newell A. Norton, and Frederick F. Wangaard as chairman. Using several recommendations of this committee in addition to many provided by the membership as well as past and present officers of A.I.W.E., President Stephen B. Preston drafted the revised Constitution.

Membership Requirements Delineated

After an extensive survey of wood technology and forest products curriculums, the membership committee consisting of Arthur F. Muschler, Robert L. Youngs, and Herbert O. Fleischer, chairman, working in cooperation with President Preston drafted the Bylaws of S.W.S.T. These Bylaws, which relate primarily to membership requirements, not only recognize the present status of education in forest products technology but also reflect the suggestions and advice of the membership as to requisite areas of training. The need for encouraging the participation and support of scientists having their primary training in related areas such as physics, chemistry, and engineering was recognized during the formative stages of *S.W.S.T.* Accordingly, the Bylaws delineate membership requirements based on education in wood science or technology, or education in a basic science or in engineering supplemented by experience in the field of wood technology. In addition, junior and student membership requirements are outlined.

Name Changed to S.W.S.T.

The name committee, made up of J. B. Grantham, Henry Huber, Gerald Prange, and Fred Dickinson as chairman canvassed members of *A.I.W.E.* as well as forestry schools and departments of forest products technology to determine the most suitable name for the organization. The survey of this committee indicated that the vast majority of those interested in the organization use the professional title of Wood Technologist. In addition, many individuals reported increased emphasis in their work on the science rather than technology of wood. From the findings of the committee the name *Society of Wood Science and Technology* was synthesized. It was felt that this name expressed the sentiment of the membership and provided a highly desirable professional connotation to the name of the Society.

Will Work Closely With FPRS

It is foreseen that this professional organization of wood scientists and technologists will provide the future leadership and rallying point for education and industry in the field of forest products. Working closely with the *Forest Products Research Society*, it will serve as an instrument for the creation of educational and performance standards for the promotion of the profession. Under the auspices of this society, qualified members will be better able to promote research in wood science and technology and encourage mutual cooperation between research and industrial efforts in the forest products field. Furthermore, the Society will provide a forum for the discussion of professional problems and exchange of technical and scientific information.

The Constitution and Bylaws of the *Society of Wood Science and Technology* are reproduced as follows. Qualified persons are invited to apply for membership. Applications for membership can be obtained from Dr. B. A. Jayne, Secretary-Treasurer, Washington State University, Division of Industrial Research, Pullman, Washington.

Constitution of the Society of Wood Science and Technology

Article I. Name

The name of this society shall be *Society of Wood Science and Technology.*

Article II. Purpose and Objectives

The purpose of this society is to establish a professional basis for the pursuit of wood science and technology. Its objectives are: (1) to promulgate qualifications for admission to the profession; (2) to foster educational programs directed toward professional advancement; (3) to establish standards of practice and ethics for the profession; (4) to promote research in wood science and technology; and (5) to provide a medium of exchange of ideas and technical information relating to wood science and technology.

Article III. Membership

Section 1. Membership shall consist of members, junior members, and student members.

Section 2. Members and junior members shall have voting privileges but only members shall be eligible to hold office.

Section 3. A member shall be a graduate of a college or university accredited by one of the six regional Associations of Colleges and Secondary Schools or of a curriculum in a foreign school judged by the admissions committee to be equivalent to one offered by accredited U.S. schools. He shall either have met the educational requirements or satisfied the permissible substitutions specified in the bylaws or shall have been advanced from junior membership according to provisions of the bylaws.

Section 4. A junior member shall be a college graduate as prescribed in Section 3 who does not meet all of the educational requirements for membership but who may be expected to qualify under conditions stated in the bylaws.

Section 5. A student member shall be a junior, senior, or graduate student and be following a course of study leading to qualification for junior membership or membership as prescribed in the bylaws.

Article IV

Dues will be assessed annually as prescribed by the bylaws.

Article V. Officers

Section 1. The governing body shall be an executive board consisting of president, president-elect, vice president, secretary-treasurer, past president, and three directors.

Section 2. The executive board shall manage the affairs of the society. It is empowered to promote the objectives of the society by receiving and administering grants and cooperating with other organizations, agencies, and individuals and to act on all other matters for which specific provision is not made in the constitution and bylaws.

Section 3. The executive board is empowered to establish such standing committees as needed to conduct the affairs of the society.

Section 4. The president is authorized to appoint such *ad hoc* committees as needed.

Section 5. The secretary-treasurer is empowered to collect dues as specified in the bylaws.

Article VI. Elections

Section 1. Officers of the Society shall be elected annually in accordance with the provisions of the following sections.

Section 2. Nominations for officers shall be made by a presidentially appointed committee consisting of three members not holding office. At least two members shall be placed in nomination for each office to be filled by the election.

Section 3. Nominations for officers may also be made by petition signed by 10 voting members.

Section 4. Election will be conducted by letter ballot sent to all voting members at least 30 days prior to the annual meeting. Balloting will be closed seven days before the beginning of the annual meeting.

Section 5. The nominee for each office receiving a plurality of votes cast for the office shall be elected. He shall assume the duties of his office at the close of business of the annual meeting following his election except as stated in Section 8.

Section 6. The immediate past president shall be a member of the executive board without election.

Section 7. The president shall hold office for one year and shall not succeed himself in office.

Section 8. The president-elect shall be advanced to president without election.

Section 9. If the presidency is vacated, the duties of the president shall be performed by the president-elect, who will advance to the presidency in the normal manner at the end of his term as president-elect.

Section 10. If the office of president-elect is vacated, it shall remain vacant until the next election at which time a president shall be elected.

Section 11. If a vacancy occurs in any other office, the executive board shall appoint a successor to complete the term of office.

Section 12. The directors shall be elected for three-year terms and these terms shall be staggered so that one new director is elected annually.

Section 13. No member shall hold two elective offices simultaneously.

Article VII. Meetings

The Society shall meet annually at such time and place as determined by the executive board.

Article VIII. Amendments

Section 1. Proposed amendments to the constitution may be submitted to the executive board by petition of at least 10 per cent of the voting members or they may be initiated by the executive board.

Section 2. The executive board shall distribute the proposed constitutional amendment among the members at least 30 days prior to the beginning of an annual meeting at which the proposal shall be approved, modified, or disapproved.

Section 3. The amendment as approved at the meeting shall be submitted to the voting members for letter ballot within 30 days after the meeting and shall be adopted if approved by a majority of members voting within 30 days.

Article IX. Bylaws

Section 1. Such bylaws as are required for the orderly conduct of business shall be proposed by the board.

Section 2. Deletions of or amendments to existing bylaws shall be proposed by the board.

Section 3. Suggestions of bylaws changes made by any voting member shall be considered for proposal by the board.

Section 4. Adoption of or amendments to bylaws shall be by a majority of members at an annual meeting or of votes cast in a mail ballot.

Article X. Fiscal Year and Financial Records

Section 1. The fiscal year shall begin on January 1 and end on December 31.

Section 2. The financial records of the secretary-treasurer shall be audited by a committee appointed by the president prior to each annual meeting and a summary statement thereof shall be submitted to the membership.

Article XI. Adoption of the Constitution

This constitution shall be submitted to the voting membership of A.I.W.E. for ratification by letter ballot. Ratification shall be by a majority of those casting ballots within 30 days after January 1, 1960. If approved, it will replace the A.I.W.E. constitution adopted June 22, 1958.

Bylaws

1. The official headquarters of the Society shall be the office of the secretary-treasurer.

2. Requirements for membership. The basic requirement for membership is professional competence in the field of wood science and technology. This requires compliance with Article III of the Constitution. Specific requirements may be met in the following alternate ways:

A. Qualification for Membership Through Formal Education

a. The following minimum background requirements must be met. 1. A foundation in mathematics including differential and integral calculus. 2. Chemistry including organic chemistry. 3. General physics including mechanics, heat, light, sound, and electricity. 4. Biology including plant sciences.

b. The following minimum requirements in wood science and technology must be met.

I. Basic Areas	Semester Hours	Quarter Hours
1. Biological studies of wood: Must include studies of anatomical structure of wood and identification of wood. Additional courses may be in such areas as wood destroying organisms, wood microtechnique, etc.	6	9

	Semester Hours	Quarter Hours
2. Physics and chemistry of wood: Includes such courses as wood chemistry, wood moisture relations, and the physical properties of wood. ---	6	9
3. Wood engineering: Must include studies of mechanical properties of wood. Additional courses may be in such areas as engineering design of wood structures, mechanical properties of wood laminates and wood-based materials, etc. -----	4	6
II. Applied Areas		
4. Wood processing: Includes such studies as seasoning of wood, adhesives and gluing of wood, wood preservation, wood finishing, and wood machining. ----------	6	9
5. Forest products industries: Includes such courses as manufacture of lumber, veneer and plywood, furniture, containers, millwork, fiber products, and chemical products; grading, quality control, distribution, sales, and economics when related specifically to wood and wood products. ----	6	9
6. Forestry: Must include studies of dendrology. Additional courses may be in areas of general forestry and forest policy. ----------	4	6

c. Application for membership shall be accompanied by an official transcript. In addition, the applicant shall list the professional courses under the six major areas of study enumerated under *b* above. Where applicable, individual courses may be listed under more than one study area by dividing credits in a manner which will realistically and without duplication show the work completed under each of the major study areas.

d. Each application must be endorsed by three *S. W. S. T.* members in good standing. One of these sponsors must be a member of the teaching staff where the applicant received his wood technology education and his endorsement will provide certification of realistic division of credits as described in *b* above.

e. For students who completed their curricula before July 1, 1964, eligibility for membership will be based upon successful completion of a curriculum in wood or forest products engineering technology, utilization, etc. at an accredited school.

B. Qualification for Membership Through Substitution for Deficiencies in Formal Courses

a. Wood science and technology graduates of accredited schools as specified in the constitution whose formal education does not include the minimum numbers of credit hours in all of the areas specified under 2*A* above may receive credit applicable to membership eligibility as follows.

1. If deficiencies exist in *one* of the background requirements (mathematics, chemistry, physics, plant science) credit earned in advanced studies, in addition to the minimum requirements in one or more of the remaining three, may be substituted.

2. If deficiencies exist in *one* of the basic areas (biological studies of wood, physics and chemistry of wood, or wood engineering) credit earned in advanced courses in the related general sciences (biology, physics, chemistry, or engineering) may be substituted for specialized courses. Creditable substitute courses will be only those over and above the foundation courses listed in *2Aa*. Courses used as substitute for background courses as specified in *2Ba(1)* above cannot be used for this purpose.

3. In the applied areas (wood processing, forest products industries, and forestry) work experience in a responsible technical position may be substituted for education in the corresponding applied area at the rate of 3 months of applicable experience for each credit hour.

C. Qualification for Membership Based on Experience

1. Through education in one of the background sciences enumerated in *2Aa* and through experience in the application of this scientific knowledge to wood, the applicant must have attained knowledge equivalent to that required of a member who qualifies through formal education in a minimum of one of the basic areas enumerated in *2AbI*.

2. In the applied areas, the applicant must have a total of 4 years of experience (earned at the rate of 1 credit hour for each 3 months of applicable experience, to the total of 16 credit hours required in the applied fields) in a responsible technical position in the applied areas enumerated under *2AbII*. Teaching or research experience in the applied areas may be credited. In the course of his experience it is considered important that the applicant have attained a practical knowledge of wood processing, wood-using industries, and forestry.

3. The applicant must have made distinct and noteworthy contributions that advance the science or practice of wood technology.

4. The applicant shall submit a statement verified by three SWST members supplying evidence as to his attainments in the basic areas and the degree of his knowledge in the applied areas and fully outlining his distinct contributions to the advancement of wood science and technology. Qualifications of the applicant will be evaluated by the *S W S T* admissions committee.

3. Requirements for Junior Membership

The basic requirement for junior membership is potentiality of qualifying for membership by substitution of experience for formal education, as provided for in *2B* and *2C* above.

A. To qualify for junior membership, the applicant must: a. Have satisfied the education requirements in *2B* and *2C* above. b. Be currently employed in a position that will permit fulfillment of the experience requirements of *2B* or *2C* within 4 years.

B. Application for junior membership shall be accompanied by an official transcript of college credits and a statement clearly indicating the degree to which membership requirements have been met and the plan for completing the requirements based on experience.

C. Each application must be supported by a letter from a member attesting the applicant's qualifications for junior membership.

D. Junior members shall be advanced to membership by application in accordance with the provisions of *2B* or *2C* above.

4. Requirements for Student Membership

Junior, senior, or graduate students enrolled in a curriculum of wood science and technology which, upon completion, will permit them to qualify for membership or junior membership are eligible. Applications must be accompanied by a supporting statement from the head of the department in which the student is enrolled. This statement must indicate how closely the student is expected to qualify for membership upon completion of the program. In the event that the program will not lead to qualification for membership, the statement must show that upon completion of the program, the student can be clearly qualified for junior membership.

5. Termination of Membership

A. Membership of any classification may be terminated by (1) voluntary resignation or (2) failure to pay dues for a period of one year.

B. Student membership is automatically terminated upon termination of education.

C. Junior membership will be terminated in 4 years or upon advancement to membership.

6. Standing Committees

A. In addition to those specified by the constitution, the following committees shall be appointed annually by the president and shall consist of members in good standing.

a. Admissions committee: The admissions committee will consist of a chairman and two members and will be responsible for reviewing applications for all classes of membership and for accepting applicants as members of the appropriate classification providing they satisfy the requirements specified in the constitution and bylaws.

b. Program committee: The program committee will consist of a chairman and additional members as needed. It will be responsible for developing and administering a suitable technical program for the annual meeting.

7. Dues Effective January 1, 1960

For members and junior members, $3.00 per year for the first three years and $5.00 per year thereafter.

For student members, $1.00 per year.

Dues shall be payable on the first of January. Members in arrears on the first of April shall be considered in bad standing and shall forfeit all privileges of membership until dues are paid.

Student members who qualify for junior membership or membership during the calendar year may advance to the appropriate grade without additional dues for the remainder of the year. Members of any grade joining the society during the calendar year will pay full dues for the year in which they join.

8. Relations With the Forest Products Research Society

The Society of Wood Science and Technology will operate in close cooperation with the Forest Products Research Society and will seek, through the attainment of its objectives, to help *F.P.R.S.* fulfill its role as a strong society representing the interests of the forest-products industry. Membership in *F.P.R.S.* is prerequisite to acceptance to membership in *S.W.S.T.* Whenever possible, the annual meeting of *S.W.S.T.* shall coincide with that of *F.P.R.S.* and the technical portion of the meeting shall be open to *F.P.R.S.* members and guests. The *Forest Products Journal* will serve as a medium of release of technical articles issuing from *S.W.S.T.* and when practical and appropriate *S.W.S.T.* shall provide necessary additional finances for release of longer articles than ones customarily published by the Journal. The *Forest Products Journal* will be a medium of release of information to *S.W.S.T.* membership.

Integration in the Pacific Northwest

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The purpose of integration is entirely economic, and should be carefully geared to the market. The sawmill is the key to workable integration. Investment is less than that required for plywood, pulp, and hardboard plants, and logs can be converted in any manner dictated by the market.

IN THE PACIFIC NORTHWEST, timber has largely been logged within reach of tide water. Once the timber is floating, the ease of movement even over long distances makes possible a form of integration that is much more complete than is generally recognized. A logger without any conversion equipment whatever can sell his peelers to a plywood plant, his saw logs to a sawmill, and pulp to a pulp mill. A sawmill can participate in integration by turning all residuals into furnish for pulp mills, board plants, power plants, etc.—all located on tide water. Navigable rivers extend this advantage many miles inland.

This may sound clumsy and costly with so much moving and handling, but it is economically necessary. If a pulp mill, as an example, used all logs as produced for its furnish there would be times when logs with a high market value would displace entirely suitable logs worth very much less. This may actually happen because of a lack of incentive within a firm to improve revenue. As an example, if a firm values all logs at the cost of production and ignores market value, the conversion plant would have no reason to sort out the higher quality log. At the production level there is even likely to be a resistance to the withdrawal of the better wood.

The need to consider integration is emphasized if a typical log mixture from a Douglas-fir show is analyzed, as shown in Table 1. Apart from the open log market, operators know that the return from a peeler will be greatest when it is peeled and the saw log when it is sawn.

An individual company can look at integration in several ways:

(a) One centrally located site with every facility for converting all types of log to the best economic advantage. Connections to all railways, deep sea shipping, and a good local market are requisite. This would usually be planned and built rather than developed a unit at a time.

(b) Build several sawmills at strategic locations, and as by-products develop add hard board, pulp, etc. in the most suitable locations with complete integration as the plan.

(c) Build sawmills and complete integration through contracts with other operations already functioning.

For the purposes of this discussion integration refers to a company equipping itself so that various types of logs and species can be converted to the maximum economic advantage without involving other firms.

The purpose of integration is or should be entirely economic. The extent of integration may well be reduced if market changes result in a better profit without it. If it should happen that someone will pay more for boomed logs than you can obtain (net) after considerable processing there should be flexibility to permit it. If rough green lumber is selling for more than can be obtained (net) through drying, dressing, etc., the firm should be prepared to market the green rough. However, the plant and equipment should be ready for use to work the log to the maximum degree if it will add to the net revenue from a thousand feet of logs. The good feature of our free enterprise system is that the profit proves the correctness of any planned move.

The sawmill is the key to making integration work; partly because some of our timber can only be used for lumber. The investment required is not great when compared to such operations as hard board, pulp and plywood. Properly installed a sawmill is flexible enough to convert logs in any

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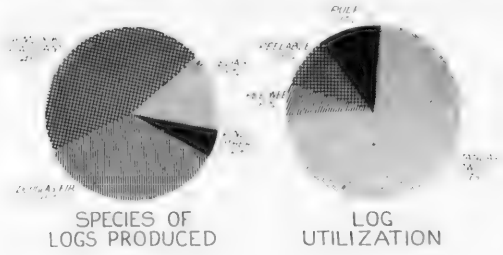
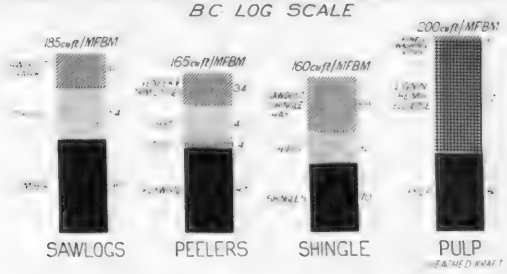
TYPICAL INTEGRATED B.C. COAST OPERATION



CUBIC RECOVERY IN CONVERSION PLANTS

B.C. LOG SCALE



manner dictated by the market. The size of a sawmill operation can vary greatly to suit small or large volumes of logs without seriously changing the efficiency. Standard sawmill machinery can accommodate the largest sizes, smallest sizes, and any species. Power requirements for a sawmill are not great when compared to other types of conversion. The sawmill is usually departmentalized so that the process can be carried through drying, dressing, special working, etc., or it can be stopped at the rough green squaring of the log. Only in a sawmill operation can parts of a log be selected for one purpose and other parts directed to another end use. In the sawmill, there is even an opportunity to sort and buck logs for upgrading to yield a better return in some other plant.

Sawmills can be considered a permanent feature in our system. Lumber is a versatile, easily worked material which satisfies in North America a need and a standard for housing that is easily the highest in the world. The use of wood for framing and for fitments such as doors and windows has hardly ever been challenged.

It is worth noting that sawmills continue to operate and continue to set volume records with a method that is at least 100 years old. This in spite of the fact that many salesmen do their best to sell other products, misrepresent grades, and overcharge users, while the industry is careless with sizes and packaging, often low lines the grades as a matter of policy, and completely disregards the users' requirements for seasoning, etc. Only very recently has the industry embarked on a promotional program which will probably represent a fraction of 1 percent of the sales value.

Under these circumstances, and assuming the industry is intelligent enough to correct many wrongs, it is reasonable to consider lumber a permanent possible outlet in the forest industry.

The chief merit in the sawmill is that it enables the operator to get more dollars out of the log than he will by any other means. While operating a sawmill, it is a reasonable step to go into more highly finished items such as mouldings, uppers for interior finish, sidings for exterior finish, glue-up wood for engineered beams. As an example, a sawmill may cut green clear cedar flitches and receive $150 per M, but by drying and processing into finish receive $200 per M, and by processing into bungalow siding receive $270 per M. After allowing for extra costs, this normally provides an extra income. It also increases the outlets and gives assurance of a sale at all times.

While the sawmill has the objective of getting the maximum lumber, it also provides an opportunity to convert residuals into saleable form at a cost comparable to the costs that a specially built plant can provide. As an example, after making all possible lumber, the waste can be chipped with a minimum of labor and provide as high a quality of chip as can be made. It is even suggested that because sawmill waste is predominantly sap wood it is as much as 5 percent superior to whole log chips.

As far as physical recovery from the log is concerned the sawmill on the average compares favorably with any other means of conversion. The figures in Table 2 demonstrate how this works out by volume per M. B. C. Log Scale.

In the comparison of dollar recovery there is a constantly changing picture affected by the slightest change in market or costs. If a peelable fir log were processed today the values might be as shown in Table 3.

The sawmill is the only means of conversion at this time for cedar, and Douglas-fir is much less attractive than other species to the pulp mills. Only kraft mills can use Douglas-fir, and then only to the extent of approximately 50 percent of the furnish.

In the Douglas-fir area, we find that in order for a sawmill to properly play its part in integration it has to be properly equipped.

Booming grounds must be laid out for sorting out unsuitable logs and for fast accurate bucking. Powered pike poles and boom dozers are important labor saving devices.

Table 1.—ANALYSIS OF A TYPICAL LOG MIXTURE IN A DOUGLAS-FIR SHOW

	Peelable	Standard	Peewee	Pulp	Total
Douglas Fir	17,500 M. (25%)	45,500 M. (65%)	4,900 M. (7%)	2,100 M. (3%)	70,000 M. (35%)
Hemlock	1,800 M. (2%)	64,800 M. (72%)	5,400 M. (6%)	18,000 M. (20%)	90,000 M. (45%)
Cedar	.....	27,000 M. (90%)	2,400 M. (8%)	600 M. (2%)	30,000 M. (15%)
Pines, etc.	.....	8,500 M. (85%)	.....	1,500 M. (15%)	10,000 M. (5%)
	19,300 M. (10%)	145,800 M. (73%)	12,700 M. (6%)	22,200 M. (11%)	200,000 M.

Table 2.—COMPARISON OF LOG RECOVERY IN SMALL PLYWOOD PLANT, SHINGLE MILL, AND KRAFT PULP MILL

	Sawmill	Plywood
Lumber	95 cu. ft.	4 cu. ft. lumber
Chips	54 cu. ft.	87 cu. ft. plywood
Bark, etc.	36 cu. ft.	40 cu. ft. chips
		34 cu. ft. sawdust, etc.
	185 cu. ft.	165 cu. ft.
	Shingle Mill	**Kraft Pulp Mill**
Shingles	70 cu. ft.	80 cu. ft. pulp fibre
Chips	32 cu. ft.	117 cu. ft. lignin, etc.
Sawdust, shingle hay	58 cu. ft.	3 cu. ft. bark, etc.
	160 cu. ft.	200 cu. ft.

Table 3.—COMPARISON OF DOLLAR RECOVERY VALUES (M) FROM PEELABLE FIR LOG

	Sawmill		Plywood		Pulp
Lumber	95 cu. ft.	$ 92.00	4 cu. ft.	$ 1.80	---
Plywood			87 cu. ft.	157.00	---
Chips	54 cu. ft.	8.00	40 cu. ft.	6.60	---
Bark, sawdust, etc.	36 cu. ft.	1.00	34 cu. ft.	1.10	---
		$101.00		$166.50	
Labor and Supplies		19.75		84.00	
		$ 81.25		$ 82.50	$40.00*

*This is price at which std. furnish is available.

The mill must have a whole log barker, preferably located in the log pond so that its operation is part of sorting and storing.

Headrigs must be mechanized so that one man can handle all functions, and equipment must be capable of producing accurate sizes to avoid waste.

Edgers, trimmers, and resaws must be equipped with mechanical aids and automation to hold labor cost and reduce waste from poor sizes as a result of fatigue of workmen.

End trimming and marketing must be tops, as it is a major help in attracting the buyer.

Kilns and drying facilities must be capable of removing maximum moisture uniformly and not damage the wood.

Planers and finishing equipment must be well maintained and top quality dressing insisted upon. Some savings of wood should be attempted in the planer mill through the use of chipper heads.

Management must be constantly developing and merchandizing new patterns and ideas for use of wood in all industries.

Sawmill people should have an interest in and support the glulam business because lumber's usefulness can be multiplied by combining it with plastics.

Storing of lumber is an important part of sawmilling. More and more the mixed car and specified lengths, etc., are required to keep lumber competitive with other products. The buyer must receive fresh, dry, clean lumber regardless of the fact that the mill has had to carry it in inventory for a period.

There have been many improvements in methods and attitudes over the past 10 years. No longer is the burner accepted as the sign of the sawmill—it is now recognized as a monument to waste. The removal of the burner not only proved to the sawmill man that extra income could be derived from material being burned but so impressed him with the volume being discarded that there has been a definite benefit to lumber recovery. With the burner removed, it is also possible to account for every cubic foot of log supplied to the mill and from its distribution judge the efficiency of the plant. In a very short time even such material as hog fuel and bark will be too valuable (for products such as particle board) to permit its use as a fuel. More automation and mechanization will reduce costs to keep wood competitive with what we call substitute materials.

Sorting Logs to Improve Sawmilling[1]

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Sawlog sorting improves efficiency of gangsaws and other headrigs, it allocates materials effectively among auxiliary equipment, improves production control, reduces inventories, improves utilization of residues, and reduces the cost of green-chain sorting.

AS WOOD USING PLANTS have become increasingly integrated, sorting various types of raw material has become more common. The separation of peeler blocks, sawlogs, poles, and pulpwood is now a familiar practice, for sound and well known reasons. Less well appreciated, however, is the fact that sorting sawlogs may help to improve the sawmilling operation itself.

Even a small modern sawmill is remarkably versatile. A simple circular headrig can turn out scores of different products from the same type of log, products that vary in species, size, grade, and subsequent treatment. These different products are usually made in an unsystematic order, and they must be segregated one or more times for further processing. The larger sawmill, with several headrigs and auxiliary breakdown machines, is among the most complex manufacturing plants on the industrial scene, if we gauge complexity by the number of alternative combinations of treatments that may be applied to raw material.

If they are sawing logs woods-run, large sawmills seldom develop fewer than 50 sorts at the green chain. At the other extreme are mills that have more than 4,000 potential green-chain sorts. Improvements in lumber sorting and handling equipment, though impressive, have not always matched the increase in sorts resulting from the more intensive use of secondary species and the need for further segregation in drying and remanufacture. The very versatility of the sawmill has thus come to be a handicap in many situations.

The problem of minimizing the number of green-chain sorts is only one of the reasons for an increased interest in log sorting among North American mills during recent years. This interest has been stimulated by the development of log handling equipment that is cheap and flexible enough to compete with the traditional log pond.

This article reviews the major purposes and methods of log sorting in Scandinavia and North America, based upon current literature, visits to some mills, and correspondence with others. It also develops the idea that log sorting may help to raise the quality of the sawyer's decision-making by reducing the complexity of his job: this hypothesis is not original, but it has so far received inadequate attention.

Sorting Logs to Improve Gangsawing

Log sorting has reached its highest level at the gangsaw mills of Sweden and Finland. Logs entering these mills seldom exceed 18 inches d.i.b., and their yield of clear lumber is low. As stumpage is dear, it is essential to make the most of each log by minimizing losses from kerf, excess thickness, and wane.

The typical Swedish sawmill solves the problem with two gangsaws in series. The first converts the log into a cant, which is then turned down and sawed in the second gang. In small mills having only one gang, logs are first canted, then returned to storage, and finally rerun through the gang after its blades have been reset for cants. Long experience and careful study have led to optimum arrangements of the saw blades (shown in "posting" diagrams) for logs of each diameter class. Improvements in yield have justified the use of half-inch diameter classes for logs up to about 12 inches d.i.b. and 1-inch classes for larger logs. So that the saw blades need be adjusted to the proper patterns only during the periods of normal saw

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ch[illegible]ge, the mill must sort its logs and accumulate at least a 4-hour supply before running a given size class. Sorting pockets are often large enough to accommodate enough logs for a full 8-hour shift (1, 19, 22).[2]

Log sorting permits such further refinements as adjusting the spacing of gangsaw blades to allow for the difference in shrinkage between heartwood and sapwood. Altogether, the fruits of log sorting and a gangsawing operation of this type may be a lumber yield amounting to 68 to 72 percent of the wood volume in the log (19).

Saws and saw blades are more economical to maintain on a diet of uniformly sized logs. Compared with mill-run logs, sorted logs wear the saw blade more evenly, and it is easier to leave the feed rolls set at a constant, optimum rate.

To my knowledge, no sawmill in North America now practices such elaborate sorting of logs as in Scandinavia. However, several gang mills have set up simplified log sorting schemes to achieve similar ends.

In Fortuna, California, Fortuna Sawmills sorted Douglas-fir into three diameter classes, run separately through a 36 by 36 log gangsaw that was set up for each class (4). The later addition of a double-circular headrig to this operation led to a fourth sort, by which all logs more than 30 inches d.i.b. were sent to the new headrig (6).

Georgia-Pacific's log gang mill at Toledo, Oregon, uses a simple size sort on second-growth Douglas-fir to improve sawing and to balance the output of the gang and various resawing equipment. Logs smaller than 16 inches d.i.b. are sawed with the gang set for two 4-inch center cuts; larger logs take three or four 4-inch cuts.

McDonald Cedar Products, Ltd., Fort Langley, B. C., uses four or five log sorts in preparing cants for its gangsaw. The basis for sorting is a combination of size and quality factors, based on a relatively strong demand for 15/16-inch western red cedar in the lower grades and a correspondingly poor market for the same material in 5/4 thickness. The gangsaw is set up for both side and center cuts to suit the size and quality of the cants from sorted logs.

A more complicated arrangement of gangsaws, modelled more closely after Swedish practice, was planned for the Elk Falls Company's new green dimension mill on Vancouver Island. Six log sorts by diameter and length permit the operator of a cut-off saw to buck the small, long logs into optimum lengths. The sorted short logs are then stored in pockets near the sawmill deck, from which they are later sent in to the gangs. Logs less than 10 inches d.i.b. are live-sawed on a log gang. The larger logs, sorted by length, go through the "tandem side," first being canted on a log gang and then going through a properly set-up cant gang (15).

The essential element in each of these arrangements is that the sorted logs are sawed on a gang that has been set up rationally for the sort. Sometimes the same result can be realized by sorting cants inside a gang mill. Where mill-run logs are of a single species and vary only slightly in diameter and quality, several gangsaws can be set up differently to handle each major type of cant. The new Ozan Lumber Company mill at Prescott, Arkansas, illustrates this technique. A band headrig normally converts all logs that will make cants into one of three types: dimension, 6-inch-board, and 8-inch-board. Each cant then goes to the proper gangsaw (14).

Sorting Among Gangsaws and Other Headrigs

Sawmills that have a log gang and either a circular or band headrig ordinarily channel small rough logs to the gang and larger better logs to the other headrig. Such sorting may take place on a single mill floor, as at the Union Bag-Camp Paper sawmill, Franklin, Virginia (12), or logs may be sent to separate mill buildings (6).

Cant gangsaws may be supplied by a log gang; more commonly, in this country, the cants are made on a circular or band headrig to which sorted logs may be sent. The latter arrangement is found in several of the larger southern pine mills. The Crossett Lumber Company, for example, has practiced this type of sorting in Crossett, Arkansas, for more than 40 years. Recent improvements in the log handling equipment in the Crossett yard have increased the efficiency of sorting and storage. Almost all the small rough logs go to the second of two sawmills, where they are either canted for the gang or split for a horizontal resaw. The Bradley-Southern Division of Potlatch Forests, Inc., makes a similar separation, but the sorting takes place in the woods. Logs suited to a cant gang are sent to a small mill at Hermitage, Arkansas, while the larger logs go to the band mills in Warren (10).

When the Thompson Falls Lumber Company, Thompson Falls, Montana, rebuilt its sawmill after a fire in 1953, sorting facilities were set up to provide an "orderly variety" of logs to an 8-foot double-cutting band headrig. Between the headrig and a 25-inch cant gang was storage capacity for up to 5,000 board feet of cants, a reserve supply for the gang when the headrig was down. Sorting the logs by grades and sizes enabled the deck operator to send in a regular mixture of logs, thus promoting an even flow of materials through the whole mill (9).

Log sorting by size is of course not limited to gang mills. A pony band headrig, not necessarily in the main mill building, may justify log sorting outside the mill (5). (In most large mills with more than one band headrig on the floor, some type of log sorting is practiced. Conventional chains, live rolls, and kickers permit sorting to some extent by species, size, or method of breakdown.)

Simplifying the Sawyer's Job

Familiarity with large sawmills may breed indifference to the demanding nature of the sawyer's job and the trying conditions under which he usually works. His fingers control hundreds of horsepower and tons of rapidly moving equipment. A slight mistake in timing can damage equipment seriously. No limit switches or other safety devices can wholly protect the sawyer from danger.

In his noisy, exposed box the sawyer is expected to be infallible. He must keep the carriage on the tracks, maintain production at all times, and recover the highest possible value from each log. We live in an age when great improvements in industrial productivity have arisen from work simplification, but the sawyer's job has generally grown more complex. Aside from his manipulative skills, he must have a thorough knowledge of the machines he operates, lumber grades and values, the materials currently needed for stock and bills, the capabilities and condition of all the auxiliary equipment in the mill, and the characteristics of the log he is now loading onto the carriage. Some of his decisions, once made, are fixed for the log; other decisions are subject to continuing review as the log opens up. The ideal sawyer in a typical large mill must have powers of analysis and decision-making that would do credit to an electronic computer. Without minimizing the remarkably fine and consistent achievements of the very best sawyers, it is reasonable to doubt that many men can maintain a performance close to an ideal level for an extended period of time. In place of this ideal, we usually find a relatively small set of sawing patterns which may only approximate an optimum quality. Sawyer-controlled setworks probably help the sawyer by eliminating the uncertainty of communicating with a blocksetter and thus giving him more time to think. However, it seems doubtful that even at best such setworks can

[2] Numbers in parentheses refer to the Literature cited at the end of this article.

simplify the inherent complexity of his work.

An analytical study of the quality of decision-making among sawyers still appears to lie beyond the interests of modern industrial psychologists, who have naturally devoted their attention to simpler and more basic problems. It seems fair to say, however, that most industrial psychologists would raise no serious objections to the following hypotheses, presented here in a purely qualitative way:

(1) A sawyer becomes progressively fatigued during the day, just as do other industrial workers. Relief periods reduce the extent of this fatigue without eliminating it.

(2) The sawyer must constantly guard against allowing fatigue or anything else to affect his control of the carriage. He is usually under some pressure to maintain production. His fatigue is therefore most likely to be reflected in a poorer level of decision-making.

(3) The difficulty of decision-making may be reduced by limiting its scope, as by dealing with a sorted or otherwise stratified group of logs during a given period or shift. This may (a) delay the onset of serious fatigue, (b) reduce its extent, or (c) reduce the effect of fatigue on the quality of decision-making. Log grades may prove useful as criteria for sorting. Upper-grade logs might best be sawed during the early part of a shift, when the sawyer could best give them the complex and variable treatment they deserve.

The sorting contemplated in this line of reasoning would usually involve species, just as in many of the examples already cited. The sawyer would still have to be familiar with all species handled by the mill, but his decisions during a given period could be reduced in proportion to the extent of sorting and storage.

Similar improvements, perhaps at a somewhat reduced level, might be expected in the performance of edgermen, trimmermen, and graders if these men were working under conditions comparable to the sawyer's.

In an account of log sorting practices at the Potlatch Forests mill in Potlatch, Idaho, Jones (23) confirmed the idea that sorting by species promotes job simplification: "Sawyers through edgermen can concentrate on their jobs and do better on one or two species than on six." A similar improvement, through a reduction in headrig settings and sawing patterns, was reported in correspondence from the Scotch Lumber Company, Fulton, Alabama.

In many sawmills where logs are now sorted, it would be hard to identify and measure the benefits that might properly be attributed to job simplification, since any such improvement would probably be confounded with improvements in other phases of the operation. This is certainly an area in which much could be learned from a few well-planned mill-scale tests of log sorting, coupled with grade-recovery and yield data on comparable groups of sorted and unsorted logs.

Log Sorting to Improve the Operation of Auxiliary Sawmill Equipment

The greatest single impetus to log sorting by species has been the increase in the conversion of sawmill residues to chips for pulping. Debarkers and chippers have become standard auxiliary equipment in hundreds of sawmills. In these mills logs of acceptable species must be separated from logs that do not yield merchantable chips. Log sorting is also used to separate species that have different pulping characteristics, such as ponderosa pine and Douglas-fir (7). In the South this type of sorting is mostly a matter of separating the chippable pine from the hardwoods, whose residues are not yet generally merchantable as chips. Hardwood logs can then be sawed while the debarker and chipper are unmanned. Where a market for hardwood chips has been developed, hardwood logs must still be sorted so that the chips can be kept separate (16).

Small second-growth Douglas-fir logs are segregated and run separately through the Georgia-Pacific mill at Toledo, permitting a reduction in labor assigned to unused resaws. Log sorting by length at this mill also facilitates the stacking of kiln charges of one species and uniform length.

Edging practice at the Elk Falls mill (15) is reportedly improved by log sorting for length, which reduces the range in the lengths of boards that the edgerman must handle.

Sorting for Inventory Control

Inventory control is a primary objective at many of the sawmills whose log-sorting practices have already been cited. Logs sorted by species, length, or grade enable sales and production people to balance output and requirements much more effectively than if logs enter the mill in woods-run order. The Hills Creek Lumber Company, of Jasper, Oregon, has found a four-way log sort at two ponds essential to its operation, which specializes in custom cutting of fractional sizes and off grades (8).

Another aspect of inventory control involves the separation of material in kiln drying. The best drying practice may require that kiln charges be segregated by species, thickness, moisture content (heart vs. sap), and perhaps by grade as well. Log sorting can be helpful in building up properly segregated kiln charges quickly and without excessive inventory.

A striking example of such savings was reported from the Potlatch operation at Kamiah, Idaho (26). In 1957 the number of species handled at the mill was reduced from seven to three, logs of other species being sent to another mill. The three remaining species were sorted to permit the elimination of a complete unstacking-and-stacking operation. Sawmill costs were cut by more than a quarter, and inventory requirements were halved, freeing about $250,000 in working capital. Net savings, after charging the additional costs of log sorting and extra transportation, were substantial.

Efficiency at the Green Chain

Reducing the number of sorts at the green chain is a likely step toward lower costs whether lumber is pulled manually (15, 16) or in some mechanized fashion. Log sorting is usually the key to reducing lumber sorting. Sorting logs and running only one or two species at a time permitted the Potlatch sawmill at Potlatch, Idaho, to limit its men on the green chain to four-pocket stations instead of 11-pocket stations. With the smaller number of pockets to cover, eight or nine men were able to handle the same 220,000 board feet of lumber daily that had formerly required 11 men when the mill handled six or seven species concurrently (23).

As green-chain sorting becomes increasingly mechanized and automated, grading will remain the only operating function requiring human judgment or discrimination (24). The greater the number of concurrent sorts, the more complicated, expansive, and expensive will be the automated green chain. Existing mechanical sorters like the Wheland and Temple-Bovay have been limited to no more than 30 or 36 sorts, for this reason (21). A new electronic BiDot green chain at the Ivory Pine mill, Dinuba, California, has only 16 sorts, but requires just one man, the grader, for normal operation (17).

Location of Log Sorting

Logs can be sorted at any convenient point from the stump to the mill. The location of sorting should seldom affect the sawmilling process itself, except that sorting at or close to the mill usually gives the mill greater control over its input in the short run. However, sawmill people frequently speak well of log sorting, provided it is done before logs reach the mill pond or yard. This attitude appears to reflect

at least in part, a desire to have log sorting charged against logging. Conversely, loggers are usually more sensitive to the difficulties and extra costs that may be added when a sawmill demands only one species to a truck (29).

In a given situation, a sound decision will naturally depend upon all the relevant factors affecting both logging and milling costs. Whether to sort and, if so, where, are questions that require a comparison between the added returns from log sorting and the additional costs of sorting.

Log Sorting Equipment

Both in Europe and America, the advantages of pond operations have declined with increasing labor costs, decreasing log sizes, and the development of more efficient fixed and mobile log handling and sorting equipment for use on land. Yet some new mills have justified ponds for both storage and sorting (6, 8), and the new Diamond Gardner forest products center at Red Bluff, California, uses a bridge crane only as an auxiliary to its pond (13). Walters' recent study of log-handling costs at western pine sawmills (27, 28) concluded that mills with established pond facilities or with room for ponds usually could not lower handling costs by shifting to tractors.

Despite these exceptions, there is a trend away from ponds and toward log handling on land. Such a shift is taking place in Sweden, marked by a reduction in the number of log sorts and an even greater reduction in manpower requirements, especially in automated sorting (11, 22). Conveyor chains, live rolls, and log kickers that can be programmed in advance are used in these sorters both here and abroad.

The most promising developments in land sorting equipment, however, have been the mobile loaders. These may be nothing more than slightly modified fork-lift trucks, transferred from duties in handling lumber and pallets. Front-end loading attachments for crawler tractors have become familiar in the woods and at landings, as well as in mill yards. Finally there are the wheeled tractors with front-end forks, tongs, or grapples, ranging in capacity from 5 to 60 tons and in cost from about $18,000 to about $100,000.

The versatility of these machines gives them varied applications in loading, unloading, sorting, decking, and miscellaneous other jobs around the mill. Consequently, it is usually difficult to assess the cost of log sorting apart from other kinds of log handling (2). The new loaders have generally gained widespread acceptance, despite high costs and frequent maintenance problems, because they can usually replace men and several other machines. Their future availability to help with log sorting seems assured.

For western pine mills, Walters' study (27, 28) indicated that a choice among pond, large tractor, and small tractor for log handling will depend on the amount of sorting required, the costs of ground preparation and log protection, and the size of the logs to be handled. Much sorting, particularly with large logs, usually favored a pond, if available, over any tractor; with small logs requiring much sorting, the small tractor usually had the advantage over large tractors. Here again, a sound decision must rest on the merits of each case.

We can expect the performance and cost characteristics of these mobile loaders to improve over the next few years.

Conclusions

Log sorting practices have already become more complex in their objectives and methods since the time when most sorting took place in ponds, solely to improve the yield of gangsaws. Present practices are quite diverse and fall into no simple pattern. The experience of progressive sawmills to date suggests that log sorting will receive increasing attention in the future,

(1) In all but the smallest sawmills, there are several reasons why it may be desirable to limit the inherent flexibility of a mill by some form of log sorting. The cost of sorting may be justified by increased returns from more efficient sawing practices, better control of production, reduced inventory requirements, better segregation of material for kiln drying, more effective use of residuals, and a reduction in the cost of green-chain sorting, whether manual or mechanical .

(2) Developments in pond operations, log storage, and fixed and mobile log sorting equipment should make sorting increasingly feasible in the future.

(3) For some purposes, the soundness of a proposed scheme of log sorting will be relatively easy to evaluate, as, for example, the sorting of logs to reduce green-chain costs. Other objectives will pose much more refractory questions, such as those involved in the potential improvement of decision-making by simplifying the sawyer's job.

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The Sawmill in an Integrated Operation

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The sawmill is only one of a number of elements essential to an integrated forest operation, but the conventional mill does not meet requirements of flexibility, economy, and versatility. New machines, new techniques, and new thinking are needed.

LET US TAKE A GOOD HARD LOOK at the sawmill we inherited, almost without change, from our great-grandfathers, and see whether or not it fits into the forest utilization picture in the light of modern knowledge. Most of you, I imagine, have heard the child's definition, "A hole is to dig". A generation ago, a correct definition would have been, "Wood is to burn or to build with". We have grown up some since then, though, and we now know that such a definition is entirely inadequate.

Every year, we see the "non-board" uses of wood expanding. In 1958, there were 43 particle-board plants in the United States. By 1960, there will be approximately 60. Paper mills are sprouting up, and older plants are expanding. A major producer of insulating board now manufactures a board made entirely from hardwood fiber. Old-line lumber companies are adding pulping facilities to their operations. This is fine! It is good conservation. It permits more intensive forestry. It is, we sincerely hope, good business. Is it reasonable to assume, though, that this expanded and more complex concept of forest utilization can best be served by essentially the same sawmill used by Desperate Desmond to quarter-saw the fair but unwilling damsel so that Hairbreadth Harry could prove his love? Let's take a look and see.

We will first paint a picture of an integrated forest operation, and then try to fit a conventional sawmill into that picture. A definition of integration, when applied to forest operations, must necessarily be quite general. People from different regions will have various specific ideas about what the term means. Let us agree that *an integrated forest operation is one in which every part of the tree finds its highest value in the available markets.* The key words here are "highest value", and "available markets". If a forest is producing only sawlogs, chemical wood, and firewood from slabs and edgings, and if these were the only products that could possibly find a market, then I suppose we would have to call this an integrated operation under our definition. In this event, the sawmill is, of course, the primary factor in integration. However, we are interested in a somewhat higher degree of diversification. Let us consider a hardwood forest in the Lake States. It is quite within the realm of possibility that within any given year, this forest will produce the following products: sawlogs, pulpwood, chemical wood, firewood, mine timbers, smelter brands, car stakes and veneer bolts. The mill drawing upon the forest will produce: lumber, railroad ties, furniture squares, chemical blocks, roofing felt chips, pulp chips, and bowling pin blanks.

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Right away we see that integration starts in the woods—it is not only a function of some manufacturing plant. We can assume that in no case will a tree be saleable as a whole either at the place where it is felled, or at any other point. We can further assume that any given tree will contain a variety of products. Thus, as soon as the tree is on the ground, separation of the products has to begin. All saleable portions of the tree have to be transported to their respective points of sale. Some will be sold at roadsides in the forest, others will go to a primary manufacturing plant, and still others will go directly to a point of final use.

It is possible, of course, to break a tree up into all of its products such as logs, pulpwood, chemical wood, dimension stock bolts, and firewood right where it is felled. Ideally, however, it is most economical to cut out in the woods only those portions which are going to be sold in the woods, and transport the rest of the tree intact to a central breakdown point, where mechanical handling equipment can be used, and where selection for product and grade can more easily be made. Several variations of this method are now being practiced in such forms as log-log skidding and hauling, tree-length skidding, and, in Russia, full-tree skidding.

When the tree (minus those portions which are to be sold in the woods) reaches the breakdown point, the effects of integration are strongly felt again. It is bucked to length and the individual pieces are either transported to a point of sale, or they are further broken down to make a saleable product. The way in which any tree will be cut up depends directly and entirely upon the available markets. If there is a market for veneer bolts, or smelter brands, or chemical bolts, those pieces will go to market after having been only bucked to length. If there is a market for pulpwood, these pieces might be debarked. Fence posts might be debarked and turned down to make them round. Mine timbers might be debarked, framed and sent to a treating plant. If there is a market for clean chips, some portions of the tree will be debarked and chipped.

Right here I would like to point out that a couple of important management decisions have to be made. Fence posts, pulpwood, mine timbers and sawlogs have to be debarked. Should you try to secure a machine that will debark the tree before bucking into these various products, or should you purchase two or three specialized debarkers? Fence posts, mine timbers, and railroad ties have to be treated before final use. Should you install your own treating plant, or should you send these products away?

If there is a market for boards, part of the tree will be sawed into boards. So there is a place for a sawmill in an integrated forest operation, but the key to the whole discussion is in the qualifying statement, ". . . if there is a market for boards", part of the tree will be sawed into boards. It is easy to say that there will always be a market for boards, and it is undoubtedly true, but will there always be a market for *your* boards?

[1] Presented at Session X, Lumber Manufacturing, FPRS 13th National Meeting, June 28-July 3, 1959 in San Francisco.

A sawmill owner has told me that the only profit he makes on his operation comes from the chips he makes from his slabs and edgings. If this is true in one case, it is probably true in others. Now can we honestly say that this man is operating a sawmill? Isn't he running a chip plant, with boards as a by-product? And, if this is the case, is the plant which was designed solely to produce lumber the most efficient for the operation as it is now carried on? Market conditions can easily change, and our sawmill operator will find that the chip tail is no longer wagging the lumber dog. The point is that in order to conduct even such a simple, two-product integrated operation efficiently, it should have built-in flexibility, and it will require the exercise of a higher order of managerial skill than is sometimes found in small operations. How much more complex are the requirements for an operation producing fifteen or more products!

This whole discussion up to this point has been aimed at proving that in a complex integrated forest operation, the sawmill is not necessarily a prime factor. Let us now examine a sawmill and see if it is suited for its role in the operation we have been discussing. The average mill has two ends—a front end where logs go in, and a back end where boards come out on the green chain. It will have an exit for slabs and edgings, and it may have a timber deck. Essentially, however, it is a board factory. It may be automated to a considerable degree—the three-man mill is becoming more and more common, but it is still a board factory.

To make this mill fit our ideal integrated operation, the first thing that has to be changed is the attitude of the sawyer. We have brought almost an entire tree to the mill, where several products were taken out of various portions of the stem. One of those products was a sawlog. This sawlog, though, is not a homogenous product. It has within it several other products, but these cannot be separated by simply bucking off portions of the log—the log has to be opened up to get at them. When we open up a log, it is almost like opening Pandora's box. We find slabs, boards of various grades and degrees of usefulness, furniture squares, railroad ties, mine timbers, chemical blocks, pulp chips, and fuel, to name a few. If the sawyer is thinking only of boards, and knows nothing of the current status of the relative values of the other products he finds inside the log, how can he do an efficient job of getting the most return from each log he opens up? Once we have succeeded in converting the sawyer to this way of thinking, we have converted the sawmill into a log breakdown plant. It goes without saying that the other members of the sawyer-edgerman-trimmerman team must be re-educated as well.

I am not fooling myself by thinking that it is going to be an easy job to change the attitudes and thinking of the men who operate the mill, but it might be easier than the job of adapting the machinery to the new concept of a log break-down plant. In the first place, changes will have to be made from the materials-handling standpoint, just to provide suitable exits for the various products coming out of the log. In the second place, the machinery itself will have to be redesigned. It would be possible to saw boards with an over-sized coping saw, but it would take forever and a day. It takes heavy, rugged equipment to run a board factory economically. This equipment is expensive, and must be kept running at full capacity all the while. You can even find yourself in the position of running the sawmill to produce boards worth x dollars, when the wood in those boards might bring x+2 dollars as chips, because it would cost you x+3 dollars to let your sawmill equipment stand idle. What are you going to do when, for a given period of time, your forest is producing pulpwood, chemical wood, veneer bolts, mine timbers, fence posts, and firewood, but almost no sawlogs? I know what you are going to do (assuming that you cannot purchase logs)—you are going to lose money on your sawmilling operation. You will get out your slide-rule and figure which of these products you will sacrifice in order to lose the least amount of money.

It should be obvious by now that Desperate Desmond's sawmill is not suited to an integrated forest operation. If it isn't then what is? Don't hold your breath waiting for me to tell you, because this is in the nature of a "key-note" address, and such papers can legitimately ask questions, but, fortunately, do not have to answer them! What I wish to do is point out the need for a great deal of engineering effort to produce the kind of equipment that will fit into the ideal integrated forest operation.

Flexibility: An operation that turns out a number of products must be prepared to shift the emphasis of its efforts to those products that return the greatest profit under conditions of varying market demand. To some extent, this is relatively easy in a forest operation, because of the overlapping of raw material requirements. For instance, nearly the whole tree could be converted to chips, if that were desirable. Likewise, the same portion of the tree that makes pulpwood also makes chemical wood, fence posts, and some mine timbers. Bolts that will make mine timbers will also make railroad ties, and logs that will produce boards will produce chips, ties, mine timbers, and chemical wood as well. On the other hand, free choice as to what will be produced is often limited by what the managed forest is sending in as raw material at the moment. As far as the sawmill is concerned, the equipment must be able to accommodate itself to a wide range in volume of production.

Economy: If flexibility is achieved, it necessarily means that some pieces of equipment will, at times, be idle, or operating at something less than optimum production. Their initial cost and their quality must be such that their useful life is appreciably longer than their economic life, in order that periods of non-use or low-volume use can be withstood.

It would seem desirable to depreciate all equipment on a unit-of-production basis, with charges against operating machines absorbing at least a portion of the charges against idle machines or those operating at less than optimum production. This is a problem for accountants.

Versatility: The equipment in the sawmill must be able to handle pieces ranging in size from something like 6 inches in diameter and 4 feet long to whatever maximum is determined by the growth habits of the species in the region. It may not be necessary to have a single machine handle the entire range, but generally speaking, it would be desirable to have machines capable of doing more than one thing.

In summary, I believe we can safely say that there is a place for the sawmill in an integrated forest operation. It must be understood, however, that the sawmill is only one of a number of essential elements, and might even be relegated to a relatively minor role in some instances. In its present state, the conventional sawmill does not meet the requirements for flexibility, economy, and versatility found necessary in an integrated operation. The concept of the sawmill as a "breakdown" plant, where portions of the tree are opened up to extract the products which nature has put on the interior of the tree will give rise to logical development of the equipment needed.

Heat Sensitivity of the Skin to Wood and Other Materials

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What makes hickory or oak handle comfortable to the touch while a metal handle at relatively the same temperature is too hot for comfort? Why does a tile floor feel colder than a wood floor? Here are the answers . . . a reliable, systematic method for evaluating the thermal sensitivity of various materials.

AT ONE TIME OR ANOTHER all of us have observed that a tile floor feels colder than a wood floor although both are at essentially the same temperature. Or perhaps we have grasped a wooden implement that has been exposed to the sun and have found it warm but not particularly uncomfortable. Under similar conditions a steel tool would be too hot to handle. These phenomena reflect the sensory perception associated with a transfer of heat between the skin and a material object.

This well-known characteristic, that results in wood being referred to popularly as "warm to the touch," is one of the important properties of wood that adds to its popularity for such uses as furniture, and even for flooring. This property, which is usually recognized or referred to only in generalities, may be referred to technically as "thermal sensitivity." But little has been published on this subject. It is the purpose of this article to present a systematic and reliable method for evaluating the "thermal sensitivity" of various materials, including different species of wood, as a means of more precise and accurate comparison.

Various suggestions have been made for the rating of various substances with respect to how they feel to the touch. For example, thermal conductivity "k" has been proposed as a measure of heat sensibility. However, this proposal is unsound because by definition "k" represents heat flow through a material under steady state conditions. It is a matter of common experience that after handling ice the hand is cool or after touching a hot surface the hand is warm, indicating a change in temperature and non-steady state conditions at the contact surface.

Another proposal involves thermal diffusivity, $\frac{k}{\rho c}$ where:

k = the thermal conductivity of the material
ρ = its density
c = its heat capacity

The coefficient of diffusivity represents the heat utilized in increasing the temperature of a substance under non-steady state conditions. It is not a good measure of the heat sensitivity of the skin in contact with a substance. It does not provide for a heat loss or gain by the skin while the substances in contact gain or lose heat depending upon their respective temperatures. In the final analysis, it is a change in temperature related to a transfer of heat at the contact surface of the skin that affects the sensory nerves and gives rise to the phenomenon that is the subject of this paper.

Recently, William F. Roeser, National Bureau of Standards, investigated the heat sensitivity of the skin to implements made of various materials. Mr. Roeser approached the problem through the solution of a partial differential equation involving heat capacity, density, and thermal conductivity of both the skin and the implement. The mathematics are beyond the scope of this paper but are covered in, "Modern Operational Mathematics in Engineering" by Churchhill. Limited experiments were in reasonable agreement with the relationships derived theoretically. In view of these studies the ratio:

$$R = \frac{\sqrt{C_A \rho_A k_A}}{\sqrt{C_B \rho_B k_B} + \sqrt{C_A \rho_A k_A}}$$

is suggested by Roeser as a measure of the thermal sensitivity of the skin to various materials. In this equation, C_A, ρ_A, and k_A are respectively the heat capacity per unit mass, the density, and the thermal conductivity of the material handled and C_B, ρ_B and k_B are the same properties of the human body. C_B, ρ_B and k_B may be considered to be the same as for water in which case $C_B = 1$, $\rho_B = 1$, and $k_B = .0014$. Therefore $\sqrt{C_B \rho_B k_B} = \sqrt{.0014} = .038$ in CGS units. While CGS units may be the simplest to use, any other consistent units may also be used. The conversion of heat capacity, and density to CGS units involves no particular difficulty. "k" in B.t.u. inch

$$\frac{\text{(hr.} \times \text{sq. ft.} \times \text{deg. F.)}}{}$$

may be converted to CGS units by dividing by 2900.

The ratio given above does not take into account differences in sensitivity between individuals, thickness of skin, callouses, or the presence of moisture or perspiration. It is nevertheless a useful means of rating various substances in accordance with human sensory perception of heat and cold.

Table 1 presents data on thermal constants and calculated thermal sensitivity (R) for oak and Douglas-fir in comparison with aluminum, iron, and concrete.

The thermal sensitivity "R" may be considered as a coefficient of comfort or discomfort depending upon the point of view. The higher the thermal sensitivity coefficient, the greater is the feeling of discomfort to the touch. Thus, aluminum, with an R value of .93 will feel decidedly cooler than Douglas-fir with an R value of .165, although both are at a normal 70° F. In the higher temperature range, an implement made of Douglas fir or other species could be handled without undue discomfort at a temperature of about 175° to 180° F., whereas a piece of aluminum would be definitely uncomfortable at a temperature of less than 120° F.

Table 1.—THERMAL CONSTANTS AND CALCULATED THERMAL SENSITIVITY (R) OF ALUMINUM, IRON, CONCRETE, OAK, AND DOUGLAS-FIR

Material	C_A Cal./Gm.	ρ_A Gm./Cm.³	K_A Cal./cm. (s. x Cm.² x °C.)	$\sqrt{C_A \rho_A K_A}$	R
Aluminum	0.214	2.5	0.504	0.518	.93
Iron	.118	7.6	.161	.38	.91
Concrete	.22	2.4	.0022	.034	.17
Oak*	.37	.62	.00042	.0098	.05
Douglas-fir*	.37	.46	.00033	.0075	.165

*Perpendicular to grain at 12 percent moisture content and 20° C.

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[1] A contributed paper received July 14, 1959.

THE DISTRIBUTION OF

Dihydroquercetin in Douglas-fir and Western Larch[1]

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A colorimetric analysis determined concentrations of dihydroquercetin at 3 levels in 9 trees. Heartwood content varied within and between trees, ranging up to 1.5 percent in fir and 1.8 percent in larch. Resinous wood had lower concentrations, and sapwood values ranged from 0 to 0.56 percent.

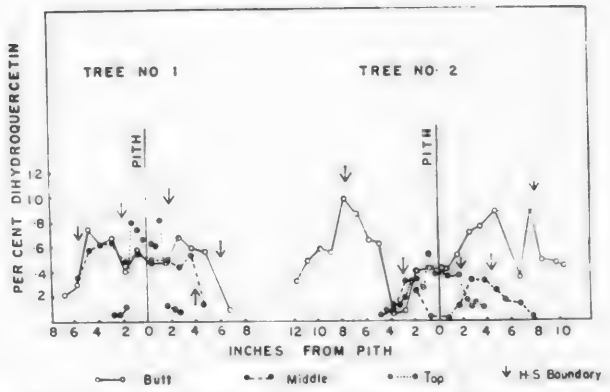

Fig. 1.—Radial analyses of Coast second-growth Douglas-fir trees.

DIHYDROQUERCETIN (TAXFOLIN) is a 3-hydroxy-flavanone (3, 3′, 4′, 5, 7-pentahydroxyflavanone) which has been shown to occur in the wood and bark of several Pacific Northwest conifers. It was identified first by Pew (1)[3] who isolated it from Douglas-fir heartwood and presented evidence that is was an anti-pulping agent for the calcium-base sulphite process. Barton and Gardner (2) noted its occurrence in western larch wood. Hergert and Goldschmidt (3) showed it to be present in the wood of Atlas cedar and Sitka spruce, as well as in Douglas-fir and western larch. Among the barks, that of Douglas-fir was found by Kurth and Chan (4) to be a rich source of dihydroquercetin, yielding as much as 7 percent.

Because of its flavonoid character and ready conversion to quercetin (5, 6), the aglycone of rutin, dihydroquercetin is potentially useful in medicinals. It has been shown to be an effective antioxidant for the prevention of rancidity in fats, oils and dairy products (7). It also has several properties that have important effects on the utilization of the wood in which it occurs. These include inhibition of calcium base sulphite pulping (8), the ability to corrode digester steel in alkaline pulping (9), and fungicidal activity which suggests that it is the dominant factor in Douglas-fir durability (10). Because of these effects and a possible bearing on wood properties, such as penetrability and gluability, and on the mechanism of heartwood formation, it was of considerable importance to establish the level of content of dihydroquercetin in Douglas-fir and western larch wood grown in western Canada and also the general pattern of variation within stems, if any. Although Pew found as much as 2.2 percent in one sample, he estimated the usual content of fir heartwood to be in the neighborhood of 1 percent. No data on the concentration in western larch wood was available, although Kondo and Furuzawa (11) reported a content of 4 percent in Japanese larch wood (Larix kaempferi Sarg.).

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[1] Presented at Session V, Chemical Utilization, FPRS 13th National Meeting, June 28-July 3, 1959, in San Francisco.

[2] A Division of the Forestry Branch, Department of Northern Affairs and National Resources.

[3] Numbers in parentheses refer to Literature Cited at the end of the article.

[4] Samples were provided by Western Plywood Co., Ltd.; Canadian Forest Products Ltd. of Vancouver; Boundary Sawmills Ltd. Midway; and Cranbrook Sash and Door Ltd

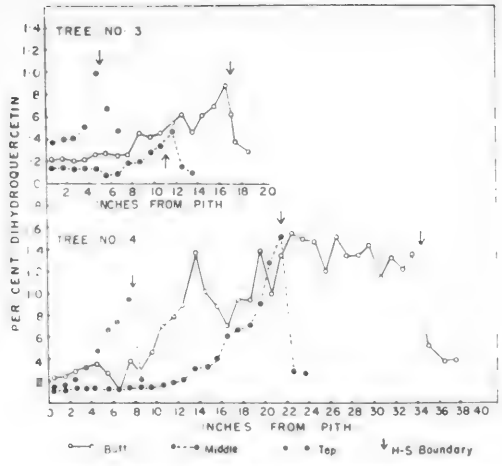

Fig. 2.—Radial analyses of Coast mature-growth Douglas-fir trees.

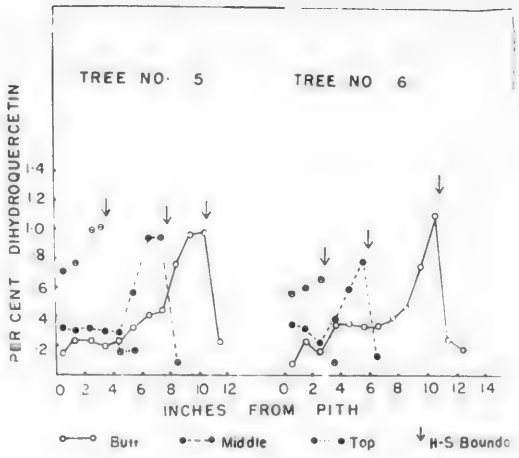

Fig. 3.—Radial analyses of interior Douglas-fir trees.

The first requirement was a method of analysis for dihydroquercetin content that could be applied routinely to small wood samples. Accordingly, a rapid colorimetric method, applicable to 2-gram wood samples was devised (12). Results obtained with this method on a 52-year old Douglas-fir have already been published by Hancock (13). The method was also used by Kennedy and Wilson (14) in analyzing a Douglas-fir cross-section exhibiting target pattern. The results reported here were obtained in radial analysis at 3 levels in 9 trees, 6 Douglas-fir and 3 western larch, harvested in British Columbia.[1]

Sampling

The trees analyzed are described in Table 1. Of the Douglas-firs, the first two may be classed as Coast second-growth, the next two as Coast mature growth, and the last two as mountain type or interior fir. Of the larches, the first was from south-central, and the last two were from south-eastern British Columbia.

Cross-sections, from 2 to 5 inches thick, were taken at 3 levels near the butt, middle and top of each tree. For analysis, a rectangular radial segment 1 inch wide was cut from each with a bandsaw. From these segments, pieces 1 square inch in cross-sectional area, unless otherwise stated, were cut, starting at the pith, and progressing radially toward the cambium. The condition, number of growth rings, and distance from the pith were recorded.

Analysis

The method of analysis (12) is based on exhaustive hot water extraction of the finely ground wood samples, and the determination of the dihydroquercetin concentration in the extract by measuring the color produced by a standardized reduction followed by an acidification procedure. The results were calculated on the weight of the wood sawdust sample, and they were corrected to a moisture-free basis, using moisture content results determined simultaneously.

In tree No. 1, Coast second-growth, the wood samples were extracted in soxhlets with methanol. The methanol extracted an additional material, however, which produced an interfering color after acidification (12). Since this color could be produced without a reduction stage, corrections were made by running parallel blank determinations, using only acidification. At this time, it was discovered that the interfering substance was not extracted by hot water, and all subsequent analyses were based on hot water extraction.

Table 1.—SAMPLE DESCRIPTION, TREES 1 TO 9

Tree No. and Species	Site	Age in Years	Diameter of Cross-section in inches			Height of Cross-section in feet		
			Butt	Middle	Top	Butt	Middle	Top
Douglas-fir								
1	Vancouver, B. C.	65	26	7	4.5	2.5	21	80
2	University of B. C.	80	26*	7*	4.5	3	60	80
3	Chehalis Lake, B. C. Elevation 850 ft.)	246	38	26	14	1.5	45	120
4	Chehalis Lake, B. C. Elevation 900 ft.)	690	76	49.5	20	2	56	200
5	Quesnel, B. C.	240	24	17.5	9	3	46	106
6	Quesnel, B. C.	229	23	18.5	8	3	37	125
Western larch								
7	Midway, B. C.	263	23.5	15.5	8.5	3	43	83
8	Cranbrook, B. C.	348	22	18	10	10	45	70
9	Cranbrook, B. C.	382	28	20	18	12	44	84

*Samples for analysis from Tree No. 2 in butt cross-section at 2.5, 3.5 and 4.5 inches from the pith and in the middle cross-section at 1.5 and 0.5 inches from the pith were extremely resinous.

Results and Discussion

The analytical results obtained are expressed graphically in Figures 1 to 4.

As might be expected, the heartwood content varied considerably within trees and between trees, ranging up to 1.5 percent in the Douglas-fir and up to 1.8 percent in the larch.

A general pattern of radial variation is evident for both species. The dihydroquercetin concentration increases from the pith toward the periphery in a somewhat stepwise irregular manner to a maximum at the heartwood-sapwood boundary. It then falls off sharply to a low but appreciable value in the sapwood. This pattern of radial increase in the heartwood appears to be a general pattern for wood extractives. This pattern has been observed with several species, such as western red cedar (15) and redwood (16). After the analytical work described herein was completed, Hancock (13), using the same method of analysis, also observed this radial pattern in one Douglas-fir stem for both dihydroquercetin and a related leucoanthocyanidin. It was also evident in the results of Kennedy and Wilson (14) on a cross-section of target pattern Douglas-fir.

A marked variation of dihydroquercetin content is also evident with distance up the stem. The effect varied from tree to tree. In most cases, the highest results were in the outer butt heartwood, but in three of the firs (No. 1, 3, 5), the highest contents were in the top cross-section. In all trees, the lowest average results were in the middle section.

The effect of resinous wood on the dihydroquercetin concentration was of interest. In the butt and middle sections of one of the coast second-growth firs (Tree No. 2, Table 1, Figure) where the wood was excessively resinous, the dihydroquercetin content

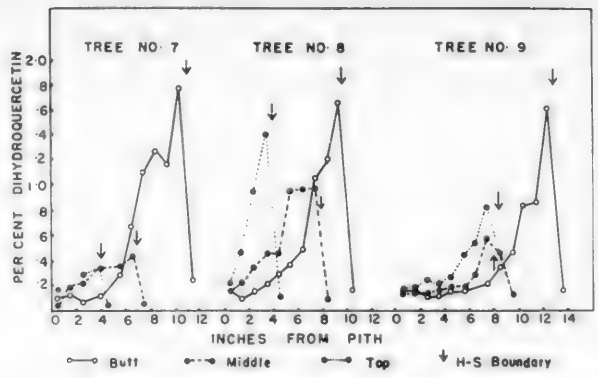

Fig. 4.—Radial analyses of Western larch trees.

considerably lower than that of normal wood adjacent to it and of wood at the same distance from the pith in the opposite quadrant. Thus, the abnormalities in the variation pattern evident in Figure 1 are assignable to the resinous condition.

In the case of the resinous samples, the analyses were repeated, using an acetone extraction procedure, to ensure that the low values were not due to failure of the hot water extraction procedure.

The results for the sapwood samples were surprisingly high, ranging up to 0.56 per cent. The absence of pulping difficulties with fir sapwood (17), its lack of durability, and experience with other species (15) suggested that dihydroquercetin would occur in very low concentration in the sapwood, if at all. In all the firs examined, however, the sapwood was 0.2 per cent or greater. In the three larches, the content was somewhat lower and never exceeded 0.23 per cent. As far as durability is concerned, the sapwood results emphasize the low fungicidal activity of dihydroquercetin found by Kennedy (10). With regard to sulphite pulping, the difficulty with fir heartwood is probably a function of both poor penetrability and dihydroquercetin content. In the sapwood, however, the relatively good penetration and the relatively lower content of dihydroquercetin makes the inhibiting effect of this phenol too small to be noticeable.

No marked differences between the results for the interior and coast mature firs are evident. While the pattern of variation was less subject to irregularities in the two interior trees, the sampling is too small to allow any general conclusions to be drawn.

Similarly there is no significant difference between the larch and fir results. While the larch samples from the outer butt had the highest contents, again the limited sample allows no general conclusion.

In all but one of the firs, the values nearest the pith were highest for the top cross-section. In Tree No. 1, all values near the pith and indeed elsewhere in the heartwood at butt, middle, and top exceeded 0.4 percent, whereas the pith values in the others rarely exceeded 0.2 percent. The overall high values for this tree compared to the others raises the question of whether dihydroquercetin contents should be determined and given consideration by forest geneticists in selecting breeding stock.

Conclusions

The dihydroquercetin content of Douglas fir and western larch varies considerably within trees and between trees. Within trees, it adheres to the general pattern of radial increase of extractives exhibited by other species. Similar variations are to be expected in related wood properties, such as resistance to calcium base pulping and natural durability. If untreated heartwood of either species must be used under conditions favoring rapid decay, material cut from near the pith should be avoided where possible. The variation between trees is sufficient to suggest that the dihydroquercetin content be measured and considered in selecting elite trees for breeding purposes.

Summary

The distribution of dihydroquercetin, a 3-hydroxyflavanone, which is an anti-pulping agent and a durability factor, has been determined in the wood of 6 Douglas-fir and 3 western larch trees grown in British Columbia. A quantitative colorimetric method of analysis, applicable to small wood samples, was used. The concentration was determined at intervals radially from pith to cambium in cross-sections taken near the butt, middle and top of of each tree. In the heartwood, the content varied considerably within trees and between trees. The values ranged from zero to 1.5 percent in the Douglas-fir and from zero to 1.8 percent in the larch. Within trees, a general pattern of increasing concentration with increasing distance from the pith was evident in the heartwood of both species. The variation with distance up the tree was inconsistent. In all cases, however, the lowest average values were found in the middle cross-sections. Resinous wood, encountered in the fir, was found to have a lower concentration of dihydroquercetin than adjacent non-resinous wood. Appreciable concentrations were found in the sapwood of both species. The values therein ranged from zero to 0.56 percent.

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LABORATORY EVALUATIONS OF

Nitric Acid Pulping of Bagasse and Softwoods[1]

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Chips, shaves, and bagasse were pulped by concentrated and dilute nitric acid, nitrogen dioxide, and solvents containing nitric acd. Weak pulps, high costs, loss of solvents, anc skimpy by-products led to the conclusion that the process i not yet suitable for small-scale production.

In pulping operations, cellulose is separated from the other parts of wood for use in the manufacture of paper. As the cellulose content of wood is close to 50 percent, there is quite a bit of reference to the "other half of the tree," and considerable research has been conducted to obtain products of use and value from this non-cellulose portion. Usually, the reference is made to bark-free wood as obtained from logs and neglects not only the bark but also the branches and tops left in the forest. Thus, there is still another portion of the whole tree from which little of value is obtained at present.

From the viewpoint of pulp manufacture, the wood contained in the tree branches and tops is as suitable as that in the main trunk, and the reason for lack of use is the expense of collecting, transporting, and preparing this bulky material. The development of portable bark removal equipment and small chipping units has made possible the utilization of the larger of these wood pieces, but the inroad on the potential remains small.

Another problem to the pulp manufacturer is the cedar found in heavy growth along parts of the Pacific Coast, particularly in Western Canada. To a large extent, this cedar is not of high enough quality to be used by the lumber industry, and it is not used in large quantities by the pulp manufacturer because it is a low density wood and raises added pulping and corrosion problems. A low density wood costs as much to handle as other wood, but it gives a lower rate of pulp production. The extractives in cedar make it a very durable wood, but they also make pulping more difficult and create a corrosion problem as a result of the iron-chelating character of the thujaplicins.

A solution to both of these problems could be provided by a pulping process that can operate in small units in the forest area. This process would have to be portable, and, in order to eliminate the wood bulk factor, it could not be a pressure process. Ideally, it would be able to handle bark-covered wood. For economical operation, kraft and sulfite pulping installations must be of a size that is too large to be considered for remote locations, and both processes require the use of pressure. The nitric acid pulping process, which does not require pressure, appears to be adaptable to small installations, and it is potentially usable on a portable or semi-portable basis. Reports on this process are conflicting, and a laboratory evaluation of several types of nitric acid pulping was carried out to determine its suitability. The results showed, in agreement with most of the earlier work, that the process can be used on a small scale, but that the cost of nitric acid consumed is too high for practical use. In reporting this evaluation, experimental details have been kept to a minimum in order to obtain a better overall view of the various results.

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The Nitric Acid Process

The history of nitric acid pulping goes back over 100 years, and in this time there have been only few cases of its use on a commercial scale. The attractiveness of pulping by nitric acid is to be found in the advantages, relative to the commonly-used processes, of being able to pulp almost any cellulosic material, of producing a high alpha-cellulose wood pulp, and of being able to pulp without the use of pressure and accompanying capital investment and operational restrictions. The main obstacle to commercial use of nitric acid pulping has been cost of the acid consumed. Since 1915, however, the price of ammonia has decreased considerably and, as nitric acid can be made fairly easily by the catalytic air-oxidation of ammonia, there has been renewed interest in the process.

Nitric acid pulping is commonly a two-step process. In the first step, the wood or other material is treated with nitric acid under various conditions of acid concentration and heat. The acid concentrations that have been used range from 1 percent to 60 percent, and the temperatures range from 85° C. to 115° C. (1,2,3).[2] Most of the various combinations of acid concentration and temperature have been tried, and those generally favored for wood pulping are either dilute acid and high temperature or concentrated acid and low temperature. The nature of the chemical reaction in this first step is unknown, but it evidently centers on oxidation of the lignin side chain along with some nitration of the lignin nucleus. The cellulose remains relatively untouched, but it does

[2] Numbers in parentheses refer to Lit Cited at the end of this report.

es e entirely the effects of oxidation, nitration, and acid hydrolysis. In the second step of the process, the treated material is extracted with dilute alkali, removing the nitrated and oxidized lignin and leaving the cellulose free. In addition to the lignin, the wood hemicelluloses are acted upon and largely removed as alkali-soluble materials, which accounts for the high alpha-cellulose content and relatively low strengths of this type of pulp.

In the work being reported, the problem was approached with the objective of finding the conditions necessary for satisfactory pulping of the wood used, then looking for the modifications needed to bring the process into the range of economic possibility. A range of acid strengths was tested, and the lower strengths were settled upon as being the more favorable for acid recovery. The raw materials used were sugarcane bagasse, the residue of crushed cane stalks from which the sugar has been extracted, and Pacific Coast cedar and hemlock.

The amount of nitric acid consumed by the process was calculated from the difference between initial and final acid strengths. Due to the formation of organic acids by oxidation during the process, the actual consumption of nitric acid was greater than that indicated. An accurate measure of nitric acid usage can be obtained by the use of nitron reagent (4), but this method was reserved for use in case a favorable level of nitric acid consumption was indicated. It was not used.

The Delbay Process

Illustrating recent interest in nitric acid pulping, the Delbay process was patented a few years ago by Miss Germaine Desorbay of Paris (3). Wood shavings or grasses are held in 42 percent nitric acid for 4 hours at about 15° C. and then treated with dilute alkali at temperatures up to 35° C to remove the modified lignin. It is claimed that wood can be used in this process without removal of the bark and that good yields of a pulp superior to sulfite pulp can be obtained at 20 percent less cost (5). A French pulp mill started operation with this process in 1955, making newsprint from straw at the rate of 20 tons per day (6). The Delbay process requires a special chipping machine for making the shaves, and this machine will handle wood in sizes down to 2-inch diameters by 6-foot lengths, which includes a major portion of tree trimmings.

In the laboratory evaluation, both shaves and chips of softwood were tested. It was found that shaves were more suitable, as had been expected, but that chips also proved satisfactory, if given a little longer acid treatment time. However, strengths of the pulps produced turned out to be lower than expected, and the acid usage was higher than acceptable for economic production. No work was done with bark-covered wood, but from observations it appeared that bark would cause no problem under the conditions of the process.

Dilute Nitric Acid

Prior to and during World War II, a nitric acid pulping plant was in operation at Wolfen, Germany for the production of high alpha-cellulose pulp from beechwood (7). In the Wolfen process, chips were impregnated under vacuum with 14 percent nitric acid at 45° C. for 3 hours. After draining, the wood was covered with hot water and held at 95° C. under one atmosphere of pressure for 7 hours, then extracted with 4 percent sodium hydroxide. Acid consumption was high, and the pulp yield was rather low. Apparently, the plant operated with government subsidy.

Some years ago, Lynch and Goss (8) pulped bagasse by soaking it in 5 percent nitric acid for 3 hours, draining, heating at 80° C. for 1 hour, and extracting with alkali. To evaluate the effectiveness of this technique with wood, hemlock chips were soaked in dilute nitric acid for 2 hours at 20° C., then drained and heated with direct steam for 2 hours. The alkali extraction consisted of 1 hour's treatment with either hot 1 percent sodium hydroxide or hot 2 percent sodium carbonate. Satisfactory defibering of the wood occurred with both alkalies, but only when the concentration of acid used had been as high as 20–25 percent. The acid consumption was 700 pounds of nitric acid per ton of wood. Pulp yields and strengths were not determined.

Better results were obtained with hemlock shaves, although a larger volume of acid was required than with chips and a larger mechanical loss of acid took place due to shave matting. Pulp yields were 45–48 percent, with pulp strengths quite comparable to those of sulfite pulp. Acid consumption was at the rate of 700–800 pounds of nitric acid per ton of wood.

The re-use of spent acid, necessary for economy, leads to improved pulping character of the liquor, apparently due to the nitrous acid content. Based on this factor and estimates of nitric acid consumption as low as 300 pounds per ton of pulp, a series of pulping with 5 percent acid was made in which the acid added to the spent liquor after each cycle corresponded to 300 pounds per ton of pulp, assuming a 50 percent pulp yield. Cedar chips were heated for 3 hours at 90–95° C. in an eight-fold quantity of acid with stirring by paddle and air steam, rinsed by boiling water, digested in 2 percent sodium hydroxide for 3 hours, and finally agitated briefly but vigorously. The pulp yield dropped steadily from 37 percent in the first cycle to 10 percent in the fourth cycle. The air stream served to oxidize nitric oxide to nitrogen dioxide. Nitric oxide is insoluble in water and therefore lost from the system upon formation, but nitrogen dioxide dissolves readily in water and is retained. Nitrogen dioxide escaping from the system was trapped and found to be less than 4 percent of the weight of nitric acid originally present, a finding consistent with literature information that nitrogen dioxide and nitric oxide are lesser products of the reduction of nitric acid (9). As nitric oxide is the only reduced form that is oxidized by air, the idea of using nitric acid primarily as a catalyst for the air oxidation of lignin is pretty well eliminated.

A similar pulping series was made in which sufficient concentrated nitric acid was added after each cycle to restore the original strength of 5 percent, and the yield of pulp from cedar chips remained constant for the six cycles run. This series also demonstrated the need for mechanical defibering of the treated wood. In the absence of vigorous agitation, the yield of screened pulp was only 25 percent, and the acid consumption under these conditions was about 1600 pounds per ton of pulp. If the pulp yield had been raised to 45 percent by mechanical defibering, as was done in later work, the acid consumption should have been about 900 pounds per ton of pulp.

Lack of reagent penetration into chips had been evident throughout the work, and variations of the procedure were tried in a search for improvement. With 5 percent acid, lengthening the time of acid treatment from 3 to 4 hours led to a small increase in the yield of screened pulp. Conversely, reducing this time to 2 hours caused a decrease in the screened pulp yield and an increase in screening. Using chips that had been treated with 5 percent acid, variations of the alkali treatment led to the interesting observation that either time or temperature could be used to obtain effective lignin extraction. Thus, 4-hour treatment in 1 or 2 percent sodium hydroxide solutions at room temperature produced the same 40–45 percent yield of screened pulp as the 1-hour treatment

in hot 1 or 2 percent solutions. No improvement in yield was affected by extending the time of the cool treatment beyond 4 hours. The significance of this observation lies in the savings of heat and the lower degree of degradation to be obtained by a cool process. Sodium carbonate, substituted for sodium hydroxide in the cool extraction, was not effective, although effective when hot.

The Desforges-McLaughlin Process

The Desforges–McLaughlin nitric acid process was announced in 1956 (10). This process uses 10 percent nitric acid containing an undisclosed catalyst and a temperature of 65–70 C. It is claimed that the catalyst stops the reduction of nitrogen at the nitric oxide level where it is easily oxidized back to nitric acid by air. It is claimed, thereby, that upwards of 90 percent of the nitric acid can be recovered for re-use and that the process produces good pulp from the chips of a variety of western softwoods, including cedar. The acid step of the process, lasting about 2 hours, is followed by treatment in 1 percent alkali at 100° C. for 1 hour.

A test of the Desforges McLaughlin procedure, lacking only the unknown catalyst, was made with hemlock chips, and it gave a poor yield of unsatisfactory pulp. When hemlock shaves were used in this procedure, good yields of pulp were obtained, only slightly inferior in strength to sulfite pulp from chips. The spent acid was fortified and used for six cycles. The first use of spent acid caused a decrease in pulp yield from 60 percent to 55 percent, accompanied by a marked improvement in defibering. Acid consumption changed with use of spent acid, rising from 1200 to 1800 pounds per ton of pulp.

Nitrogen Dioxide

Nitrogen dioxide gas has been used directly on moist wood as a pulping agent (11, 12). The gas dissolves in water to form a mixture of nitric and nitrous acids, and in an operation in which the catalytic oxidation of ammonia is the source of nitric acid, use of the gas would eliminate the acid-making step. The results obtained with chips were not sufficiently promising to encourage further work, and attention was turned to the use of shaves. Tumbling moist hemlock shaves were treated at room temperature with a quantity of nitrogen dioxide equal to 10 percent of their weight for 1 hour. The gas was diluted with air, which served to disperse the gas and to oxidize the nitric oxide formed. The wood failed to defiber after 6 hours in hot 2 percent alkali. When heat was used, in the form of direct steaming after the nitrogen dioxide treatment, defibering was still unsatisfactory. However, when sugarcane bagasse was treated in the same manner, including steaming, excellent defibering was obtained, and the strength of the resultant pulp was comparable to that of bagasse pulp made by the kraft process. Apparently, sugarcane bagasse, the residue of crushed stalks left after extraction of the sugar, is in a finer state of subdivision than wood shavings. The bagasse used had been treated mechanically to separate the pith from the fiber. The nitric acid bagasse pulp was produced in 44 percent yield. The kraft process produces pulp from the same type of bagasse in 55 percent yield.

Process By-Products

It has long been known that formic, acetic, and oxalic acids are formed in the nitric acid process and that by adjustment of conditions oxalic acid can become the main product of the reaction (4). In this work, the separation of nitrolignin from the spent liquors was examined briefly. Acidification of spent alkali liquor caused formation of a dark, mud-like precipitate in the amount of 21 percent of the original weight of hemlock shaves used. As a 53 percent yield of pulp had been obtained from this wood, the weight of precipitate showed that more than half of the spent liquor solids had been rendered soluble in water by the process. The insoluble part, the precipitate, could be collected by filtration only with considerable difficulty and was best separated from the solution by centrifugation. Qualitative tests showed that the precipitate consisted primarily of a nitrated carboxylic acid, or acids. Nothing further was done with this material, other than determining a good technique for collection. It would be of interest to determine its value as a fertilizer. Its fuel value would be poor, at best.

Use of Solvents

Nitric acid pulping is a two-step process because many of the lignin degradation products are not soluble in the water of the nitric acid liquor but do dissolve in alkali. A two-step pulping process has many disadvantages, including the costs for extra equipment and heat and the likelihood of carry-over of some of the medium from the first step into the second. A solution to the problem would be a medium that can disperse the nitric acid and also function as a solvent for the degraded lignin. The organic solvent, dimethyl sulfoxide, which has substantial lignin solvating character, was tested and found to be excellent as a nitric acid pulping medium for chips. However, strengths of the pulps formed were lower than those of sulfite pulp, acid consumption was excessive, and recovery of dimethyl sulfoxide was a problem. The removal of dimethyl sulfoxide from the pulp could be accomplished easily by washing with water, but raised the problem of redeposition of lignin on the fibers as the solvent was diluted. This was best solved by first washing with fresh dimethyl sulfoxide, which increased the amount of solvent used. Recovery and purification of the dimethyl sulfoxide could be done by distillation at reduced pressure, first to remove the water, then to purify the solvent. In all, costs of solvent loss, heat, and nitric acid consumed became prohibitively expensive.

The excellence of the defibering obtained with dimethyl sulfoxide prompted an investigation of the nitroparaffin solvents, which would be recovered more easily. When nitromethane was used in place of dimethyl sulfoxide several points were noted: Presence of water was necessary for reaction; Temperature of reflux was 80–82° C., much lower than the temperature of the dimethyl sulfoxide reaction; Time required was 6 to 8 hours; Minimum liquor ratio needed was ten to one; and, Weight of acid required was almost equal to the wood weight. The nitromethane in the liquor and rinse was distilled with steam, leaving behind a small amount of gummy, orange, water-insoluble residue. Nitromethane dissolves in water to the extent of nine parts per hundred, and it could be considered that about one-tenth of the steam distillation residue and one-tenth of the aqueous phase of the distillate were also nitromethane. By combining and vacuum-distilling the aqueous phases, it was possible to raise the recovery of nitromethane to 95–96 percent.

The water solubility of 2-nitropropane, two parts per hundred, suggested the probability of improved recovery. When substituted for nitromethane the pulping action was less satisfactory, and the recovery of solvent was not improved. 1-Nitropropane is similar to nitromethane in water solubility. It was not investigated.

Conclusions

With the price of nitric acid at 4 cents per pound, the single major deterrent to commercial use of nitric acid pulping is cost of the acid consumed. Still, the process may find application in time as a result of

changes in the economic and raw material situation. The mechanism of the process is largely unknown, and there is always the possibility of finding the key to lower acid consumption. Desforges and McLaughlin claim to have found such a key, but with their finding still under wraps it is impossible to test their claim.

Although nitric acid pulping appears the most likely of the known pulping processes to find successful application on the small scale required for utilization of timber operations was . its use for this purpose involves the problems of bark and of waste liquor disposal. While bark does not appear to be a mechanical problem, there is undoubtedly an upper limit of bark tolerance in terms of greater acid consumption. The need for disposal of pulping wastes imposes a severe limitation on location, and hence mobility, of the process.

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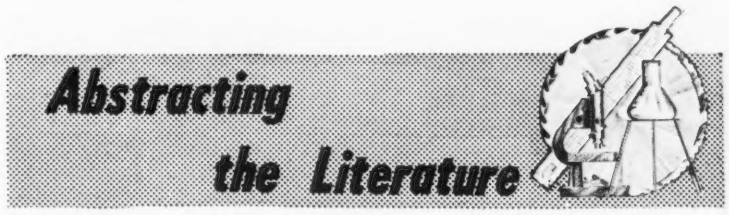

Decay Fungi

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The effect of *C. globosum (1)* on the bending strength and toughness of *Fagus sylvatica* wood was compared with the effects of a white rot (*Polystictus versicolor*) and a brown rot (*Coniophora cerebella*). *I* resembled basidiomycetes in causing a marked decrease in total work (i.e. the energy absorbed to total fracture in bending) before significant wt. losses occurred. Redns. in ultimate bending strength were more gradual and insignificant until definite wt. losses were evidenced. In its effect on the impact resistance of beechwood, *I* resembled the white rot rather than the brown rot. 14 ref. (A.B.I.P.C.)

Lamberts, K., and Pungs, L. The application of high-frequency heating in the particle board industry. Composite Wood (India) 5, no. 2–3: 17–31 (March–May, 1958).

The use of dielec. heating, rather than contact heating, in the mfr. of wood-particle board was investigated in order to det. possible savings in time made possible by high-frequency heating, to det. the power requirements in connection with the savings in pressing time, and to justify the process economically. The heating methods studied included high-frequency heating alone directly in the press without any addnl. contact heating by pressing plates; high-frequency preheating of the wooden chip mass outside of the press, combined with contact heating alone within the press; and combined high-frequency and contact heating during the pressing process. In gen., it was found that the increase in prodn. vol. achieved through dielec. heating offsets the costs involved. Existing equipment for use in dielec. heating is also discussed. 5 ref. (A.B.I.P.C.)

Properties

Buro, Andreas, and Buro, Eva-Anne. Pathways for the penetration of liquids into pinewood. Holzforschung 13, no. 3: 71–7 (Aug., 1959). [Ger.; Engl. sum.]

In the axial direction of pinewood (*Pinus silvestris*), liquids passed through the bordered pits and the resin ducts, without significant differences between the permeabilities of spring- and summerwood. However, neither water nor hot paraffin (oil) could penetrate into heartwood summerwood, whereas both liquids penetrated slightly into springwood. The axial and radial resin canals of sapwood were penetrated by water but not in gen. by paraffin. Resin ducts of heartwood were impermeable. In the radial direction, the liquids could also pass through the ray tracheids. Parenchymatous cells did not appear to be open to liquid peneration in the radial direction. Intercellular spaces in the rays were only locally important for the distribution of the liquids. The position of the torus was not the sole factor responsible for the penetrability of the tracheids; extraneous substances deposited within the cells also contributed significantly. The effective penetration of liquids in one (morphol.) direction was also affected by satisfactory penetrations in other directions. A liquid can thus by-pass local impermeable regions without being impeded in its penetration. 12 ref. (A.B.I.P.C.)

Rendle, B. J. and Phillips, E. W. J. The effect of rate of growth (ring width) on the density of softwods. Forestry 31, no. 2: 113–20 (1959); Biol. Abstr. 33, no. 12: 3914–15 (Aug. 20, 1959). [Abstr. only available]

The relation between rate of growth and d. has been examd. in fairly wide-ringed Douglas-fir (*Pseudosuga taxifolia*) and Corsican pine (*Pinus nigra* var. *calabrica*) grown in the south of England. A comparison between wood formed early in the life of the tree and wood of similar ring width formed later showed that the latter is invariably denser, indicating that the higher d. of older wood is due to an age effect rather than to diminishing ring width. It is concluded that after a certain age rapid growth can produce wood of reasonably high d. Hence Turnbull's findings on widely spaced exotic softwoods grown in South Africa can be applied, with some reservations, to trees grown in England under conditions where rapid growth can be maintained. J.S. (A.B.I.P.C.)

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